IEEC Institut d'Estudis Espacials de Catalunya

Annual report 2023

Cover Image: The Bubble Nebula, also known as NGC 7635, is an emission nebula located 8 000 light-years away. This stunning image was observed by the NASA/ESA Hubble Space Telescope to celebrate its 26th year in space.

Credit: NASA, ESA, Hubble Heritage Team

INDEX

FOREWORD

The document you are about to read contains a summary of the main activities, results, and events produced by the IEEC and its members throughout 2023. Looking at the year as a whole provides an excellent opportunity to reflect on and celebrate the numerous accomplishments. The amount of news and information in this report demonstrates the restless activity of everyone at the IEEC.

The year started off strong with the thrilling and successful launch of the Menut cubesat mission from Cape Canaveral on 3 January 2023. This is the second nanosatellite of the NewSpace Strategy promoted by the Government of Catalonia, and the first devoted to Earth Observation. Throughout the year, several images were acquired thanks to the excellent work of the IEEC, in collaboration with the Cartographic and Geological Institute of Catalonia and the company Open Cosmos. In the NewSpace field, it is also worth mentioning the Catalonia AI4EO event the IEEC co-organised to discuss the application of artificial intelligence techniques to Earth observation. The gathering was extraordinarily well attended, with members of both the academic and industrial communities. These are just some examples of the many activities developed in the framework of the NewSpace domain, the detailed account of which you can consult in this report.

The year 2023 saw the 5th IEEC Forum, which is steadily becoming a tradition. The event took place at Cosmocaixa and offered the chance for everyone to share results, discuss science and, of course, interact with friends and colleagues. Regarding meetings and congresses, the IEEC also participated institutionally in the Space Tech Expo Europe (Bremen), the International Astronautical Congress (Baku), and co-organised the New Space Economy Congress (Barcelona).

This year has been, once again, extraordinarily productive both in terms of inputs and outputs. Not only our IEEC members have managed to publish 419 peer-reviewed articles, but also 91% of them have appeared in first-quartile journals in terms of impact factor. Furthermore, the vast majority of our published results have been made openly accessible to everyone following our open science policy. You will find a full statistical report in the Publications section below, and you can have a taste of the science results in the Science Highlights section, covering topics within astrophysics, cosmology, Earth observation and navigation.

The IEEC manages the Montsec Observatory (OdM) and 2023 saw the facilities performing with the highest standards in terms of efficiency and productivity, with several upgrades implemented. Not only we achieved record-high useful observation hours and publication outcomes but we also actively participated in numerous outreach activities celebrating the Joan Oró year.

IEEC members participate (and have leadership roles) in a wide variety of scientific space missions and ground-based instrumentation projects, addressing areas such as cosmology, astrophysics, astrometry, exoplanets, compact objects, gravitational waves, reflectometry, Earth observation, Earth navigation, massive data, etc. A subset of these are considered “Key Projects” because they are of special relevance, most importantly because they involve participants from several research units. During 2023, Key Projects were the space missions Ariel, Euclid, Gaia, LISA and Plato. Specific articles in the present report describe these projects and provide updated information on the important milestones achieved throughout the year.

A particular note goes for the PhotSat project, a space mission being fully developed in house at the IEEC. PhotSat will carry out a photometric 2-day cadence scan of the 10 million brightest stars. This is a very ambitious and challenging, yet also extremely motivating, objective for everyone at the IEEC. Year 2023 was key for this project, with all the design activities moving forward at full steam.

Knowledge transfer and innovation is an essential activity within the IEEC. Our Knowledge Transfer Office (KTO) and Project Management Office (PMO) have set up direct contracts and agreements with industry, with agencies and government entities, and with European consortia within the Horizon Europe program, and oversees and provides guidance in areas such as project planning and budget control. The main topics of such contracts cover areas such as navigation, ground-based instruments, space transportation, space safety, or even talent and education. Within this scope, and in collaboration with our Communication Office, the IEEC co-organised the local edition of the 6th CASSINI Hackathon, held simultaneously in 10 European countries. You can check many other talent and outreach activities in the corresponding section of this report. Furthermore, a quarterly newsletter edited by the Communication Office is distributed by e-mail to IEEC members and keeps us all informed on the latest events and developments.

At the institutional level, major news of 2023 was the restyling and content upgrade of the IEEC and Montsec Observatory webpages. The new modern look & feel together with a friendly design provide a much-improved user experience, featuring a broad range of information on the institution, projects, events and calls.

Finally, I would like to wholeheartedly congratulate the IEEC members that have received awards and recognitions during 2023, and all the PhD students who defended their theses, also reported here. This is a perfect tribute to the world-class quality of the work performed. Further, I hereby take this opportunity to thank each and every one of the members of the IEEC for their continuous commitment and for their key contribution for the institute to reach in 2023 the highest excellence levels. It is an honour and a pleasure to work with you side by side.

CONTACT PERSON

Ignasi Ribas,
Director
director@ieec.cat

Presentation

PRESENTATION

The Institute of Space Studies of Catalonia (IEEC - Institut d'Estudis Espacials de Catalunya) is a centre that promotes the development of activities related to space in Catalonia in its aspects of research, innovation, and training.

The IEEC collaborates and participates in the planning, execution, dissemination and transfer of knowledge of all kinds of initiatives, studies and projects related to space scientific research and technology.

The IEEC is a non-profit foundation from the Catalan public sector that was established in February 1996. It has a Board of Trustees composed of the Generalitat de Catalunya, the Universitat de Barcelona (UB), the Universitat Autònoma de Barcelona (UAB), the Universitat Politècnica de Catalunya - BarcelonaTech (UPC), and the Spanish Research Council (CSIC). The IEEC is also a CERCA centre.

The research structure is in the form of four units, each belonging to one of the Trustee academic institutions, which constitute the core of the R&D activity. The Research Units are:

- Institute of Cosmos Sciences of the University of Barcelona - ICCUB
- Centre for Space Studies and Research - CERES (UAB)
- Research Group in Space Sciences and Technologies - CTE (UPC)
- Institute of Space Sciences - ICE-CSIC

Scientists and technicians from the Research Units can simultaneously act as members of their institutions and as members of the IEEC. All senior scientific personnel at the IEEC are affiliated staff members from one of the Research Units.

The organisation chart of the IEEC is shown in Figure 1. The Board of Trustees is the highest governing body of the IEEC. Its members appoint a Director, who is assisted by a Research Board. The organisation of each Research Unit is independent and the four directors are members of the Board of Directors. Furthermore, an external Scientific Advisory Board (SAB) is nominated by the Board of Trustees with the mandate to evaluate the quality of the scientific and technical outputs and advise on the strategic planning of the IEEC, as well as on the overall organisation. The research and management structure of the IEEC is organised through 4 general areas and 13 offices with clearly defined roles and responsibilities. The Research area is composed of three departments covering the main science and technology activities of the IEEC.

The IEEC has taken up a leadership role in the implementation of the New Space Strategy of the Catalan Government. Therefore, a managerial and advisory structure is implemented to optimally fulfil the associated responsibilities. In particular, the *Advisory Board for the promotion of the space sector* provides monitoring and guidance, and constitutes an interface with the industrial ecosystem in Catalonia.

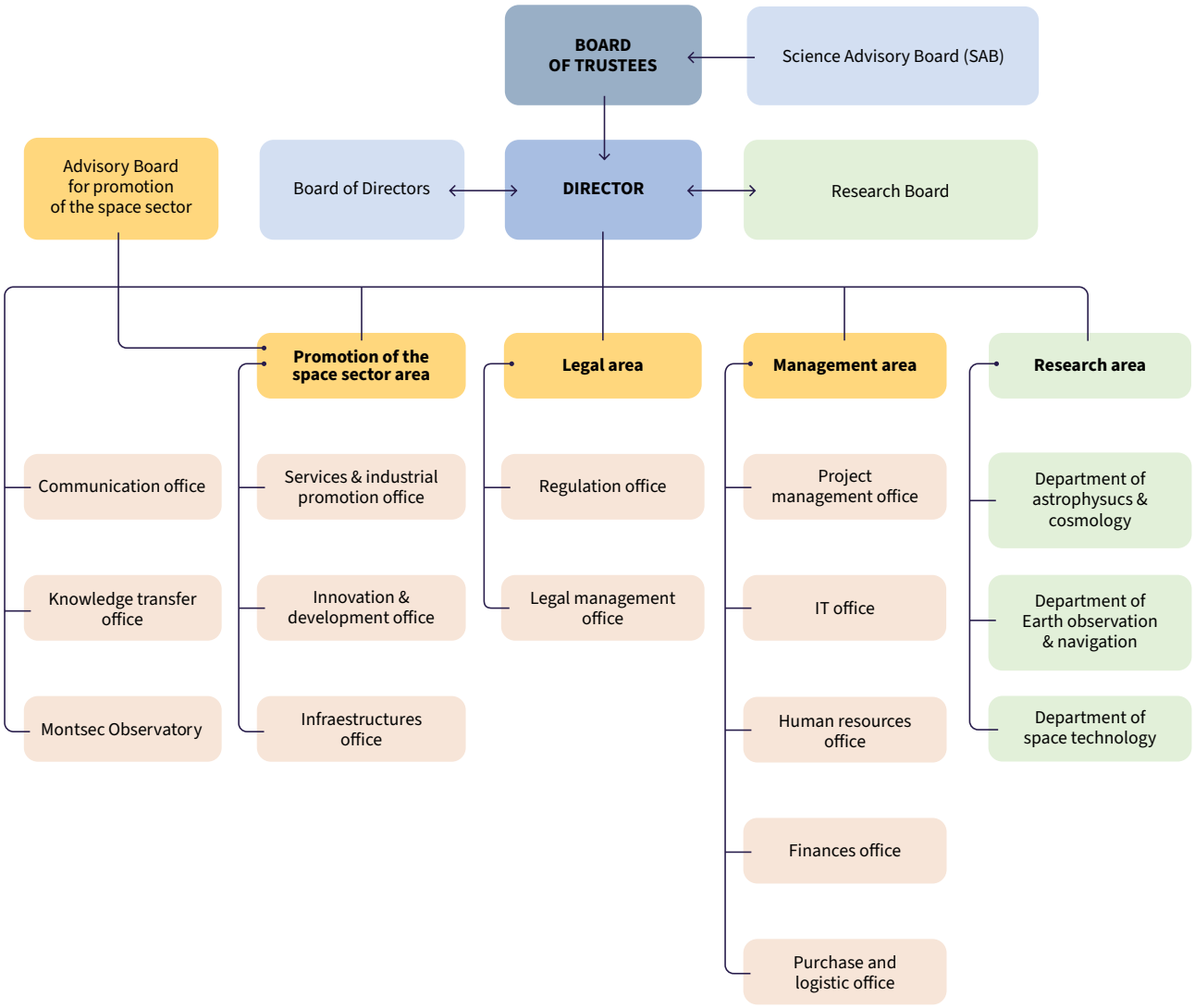


Figure 1: IEEC organisation chart

The IEEC focuses its efforts on the study of the Cosmos and the Earth as a planet, through a powerful programme for research, development and technological innovation in the framework of scientific missions and projects. The Institute participates and has high-level responsibilities in multiple space missions and ground-based instrumentation facilities, as can be seen in Image 1. The research lines developed by the IEEC belong to the three different following fields.

Astrophysics and Cosmology

The IEEC conducts cutting-edge research in the fields of Astrophysics and Cosmology through the use and development of advanced technologies such as instrumentation for ground-based telescopes and space missions, as well as tools for analysing large volumes of data. It also establishes strong multidisciplinary connections with various areas that include particle physics, geology, biology and mathematics. The main areas are: the determination of the large- scale structure of the Universe; the detection and measurement of gravitational waves; the analysis of the most energetic astrophysical phenomena; the understanding of how stars form, evolve, and die, as well as the resulting compact objects; the study of the physics of the Sun and its relationship with the Earth; the characterisation of the formation, evolution, and architecture of our galaxy and other galaxies; the search for new exoplanets with potentially habitable conditions; Mars exploration; the interpretation of the role played by the interplanetary environment; and the tracking and study of the asteroids, comets, and meteorites that surround us.

Earth Observation and Navigation

The IEEC develops new concepts of remote sensing for Earth Observation and optimization of Global Navigation Satellite Systems (GNSS). The main areas of activity are: Earth Observation instrumentation; measurement of Earth's surface and atmosphere and monitoring of natural hazards through reflectometry, radio- occultations with sources of opportunity, and GNSS data; combination of GNSS and wireless communications (including 5G) for smart cities and intelligent vehicles; advanced radiometric and hyperspectral data acquisition and processing technologies; and the synergy and fusion with other Earth Observation products and technologies, through the optimal exploitation of aerospace infrastructures.

Space Technology

The IEEC is a leading centre in the construction of space instrumentation in different areas of scientific and technological research of national and international programs. The Institute leads technological development projects for ground- and space-based instrumentation in technologies for telecommunications sensors and subsystems, electronic systems and control and processing software, platforms for nanosatellites, robotics and artificial intelligence, or Big Data tools for data management, analysis and exploitation, among others. In addition, the IEEC participates in the European and international networks that define the roadmaps of the agencies and organisations for future missions.

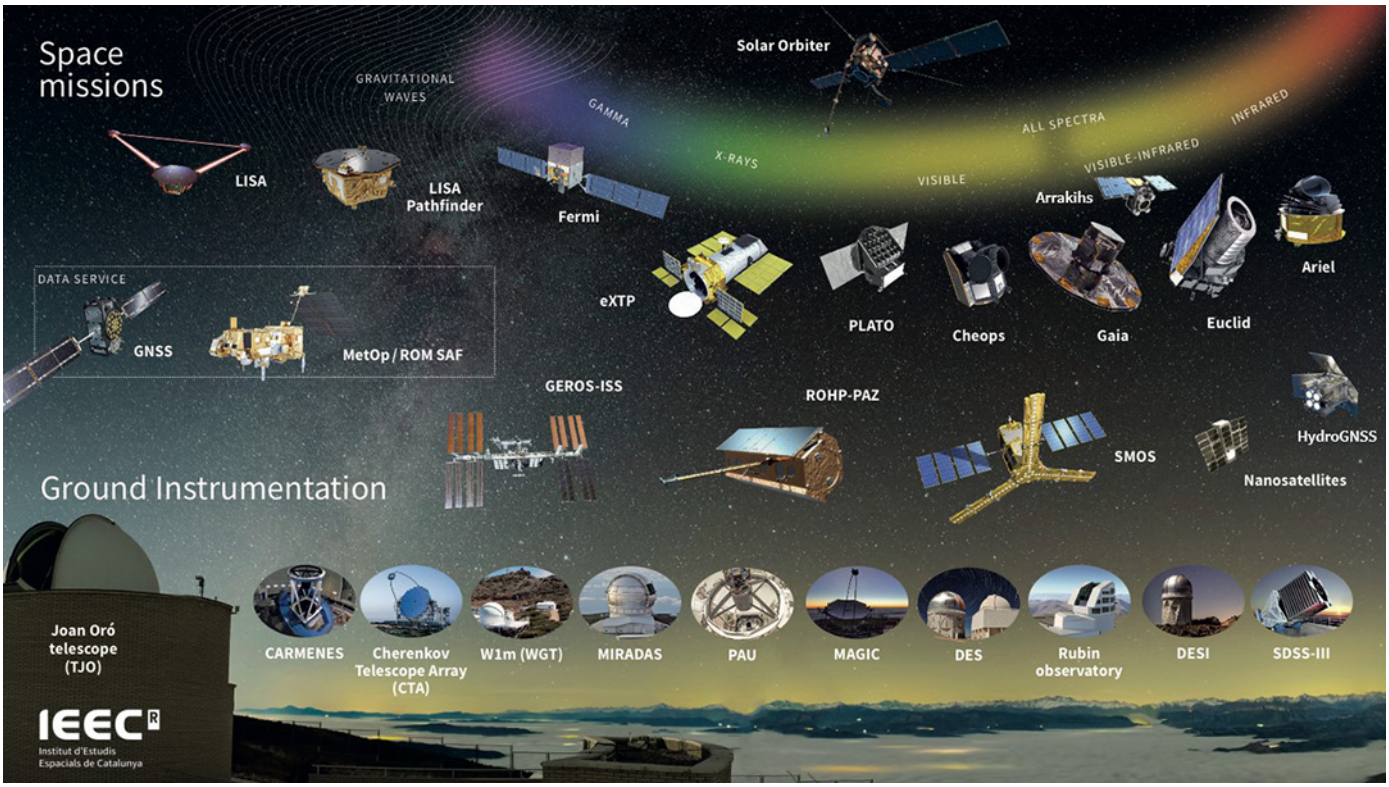


Image 1: Main space missions and ground based instruments with the IEEC participation.

Personnel

PERSONNEL

The statistics, tables and graphs illustrate the distribution of IEEC's personnel according to their work situation, gender, research unit and role.

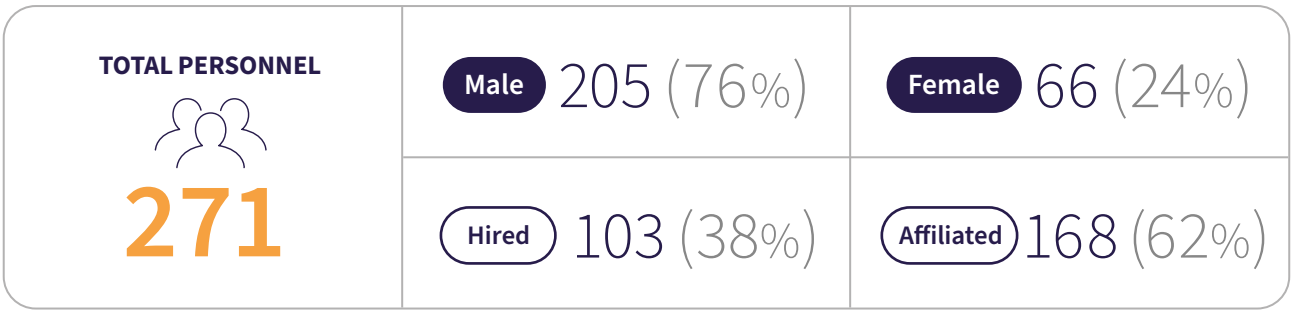


Figure 2

IEEC Contracts

Administration / Services	**20**
Management area (+ IT)	**12**
Legal area	**3**
Communication office	**3**
Knowledge transfer office	**2**
Academic	**60**
Faculty	**4**
Researchers & engineers	**42**
Postdoctoral researchers	9
Research engineers	33
Support personnel	**9**
PhD Students	**5**
Montsec Observatory	**5**
Area for the Promotion of the Space Sector of Catalonia	**18**

Table 1

Affiliated members	ICCUB	CERES (UAB)	CTE (UPC)	ICE-CSIC	TOTAL
Administration	2	0	0	0	**2**
Faculty	30	9	25	22	**86**
Researchers & engineers	19	5	2	17	**43**
Postdoctoral Researchers	10	3	1	11	25
Research Engineers	9	2	1	6	18
PhD Students	14	1	4	18	**37**
TOTAL	**65**	**15**	**31**	**57**	**168**

Table 2

Personnel by hiring entity

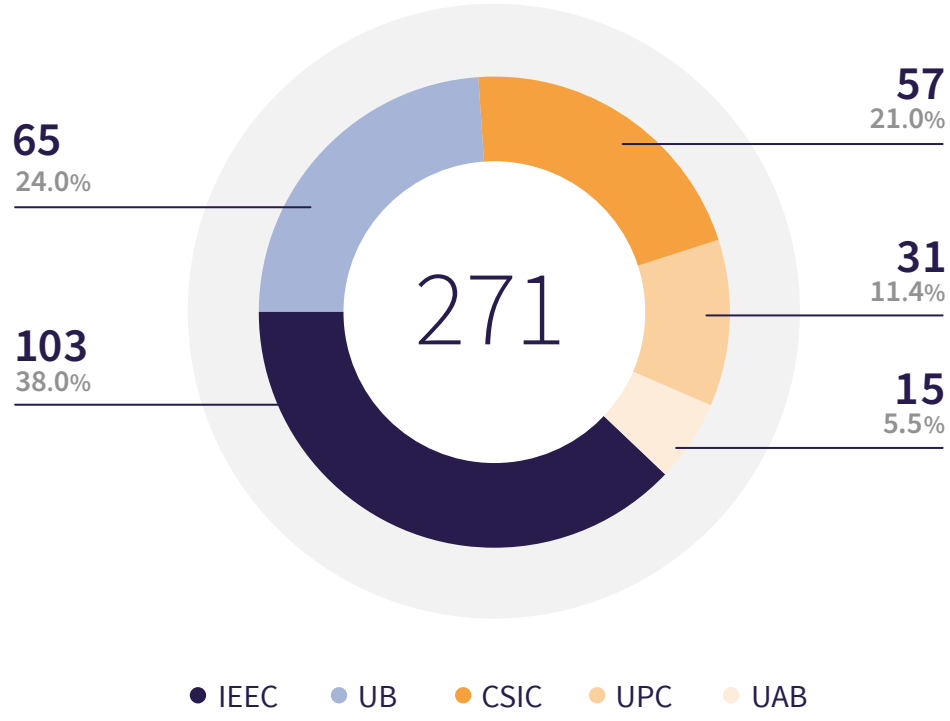


Figure 3

Personnel according to workplace

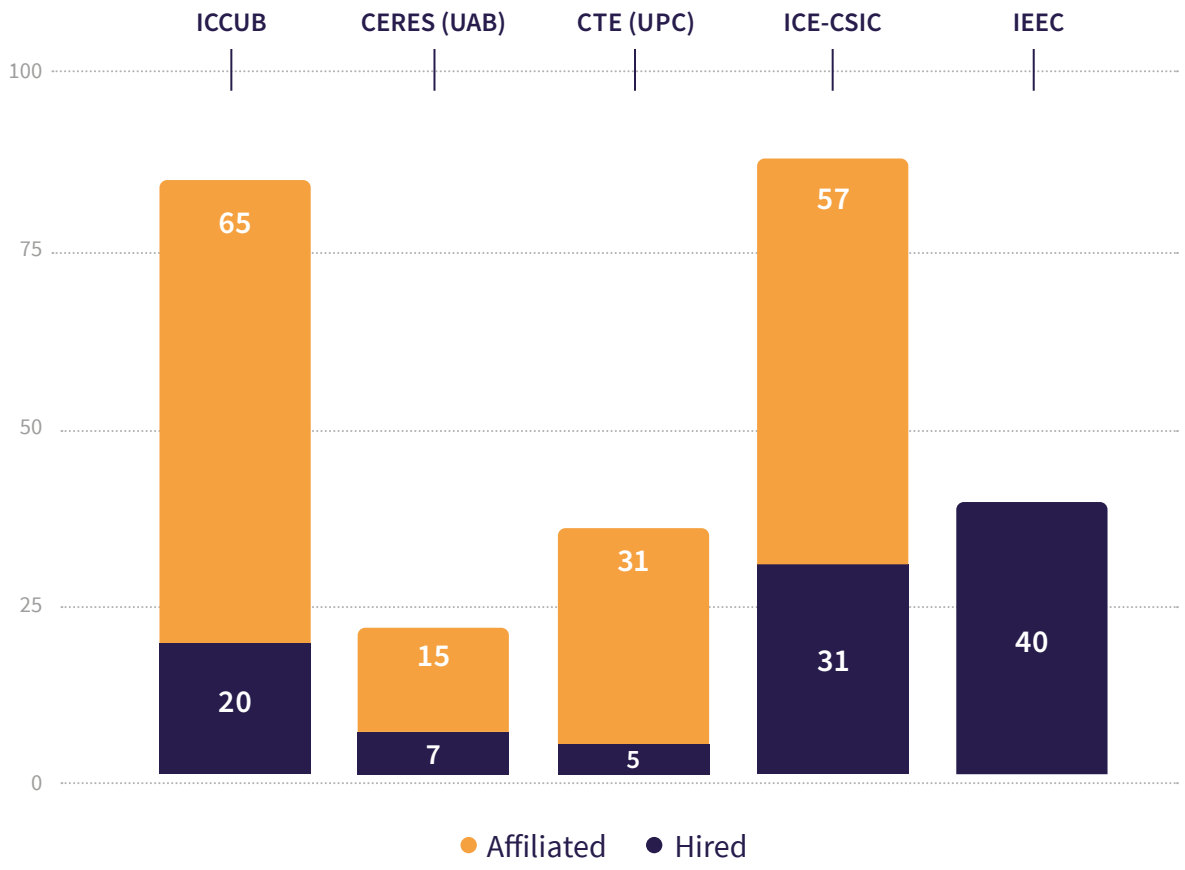


Figure 4

Personnel according to work situation and gender

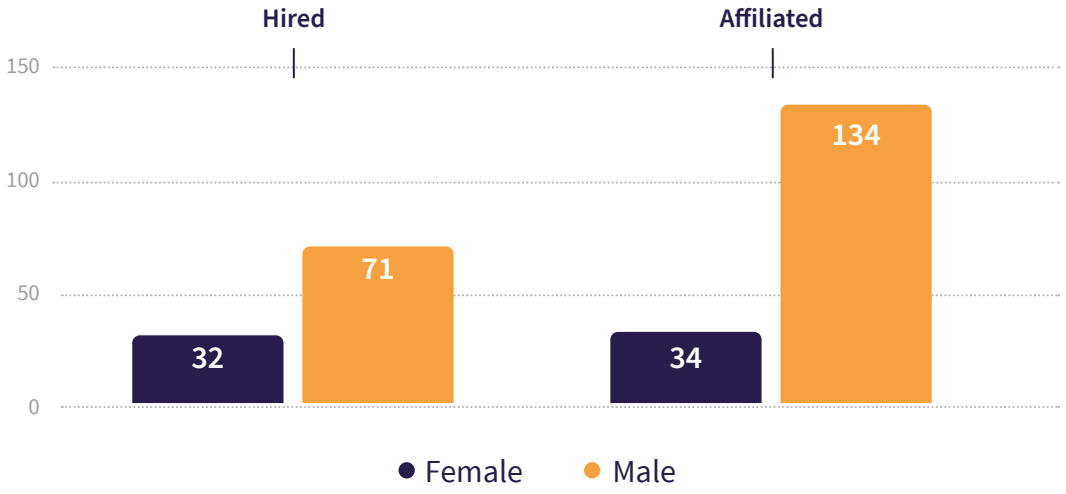


Figure 5

Personnel by role and gender

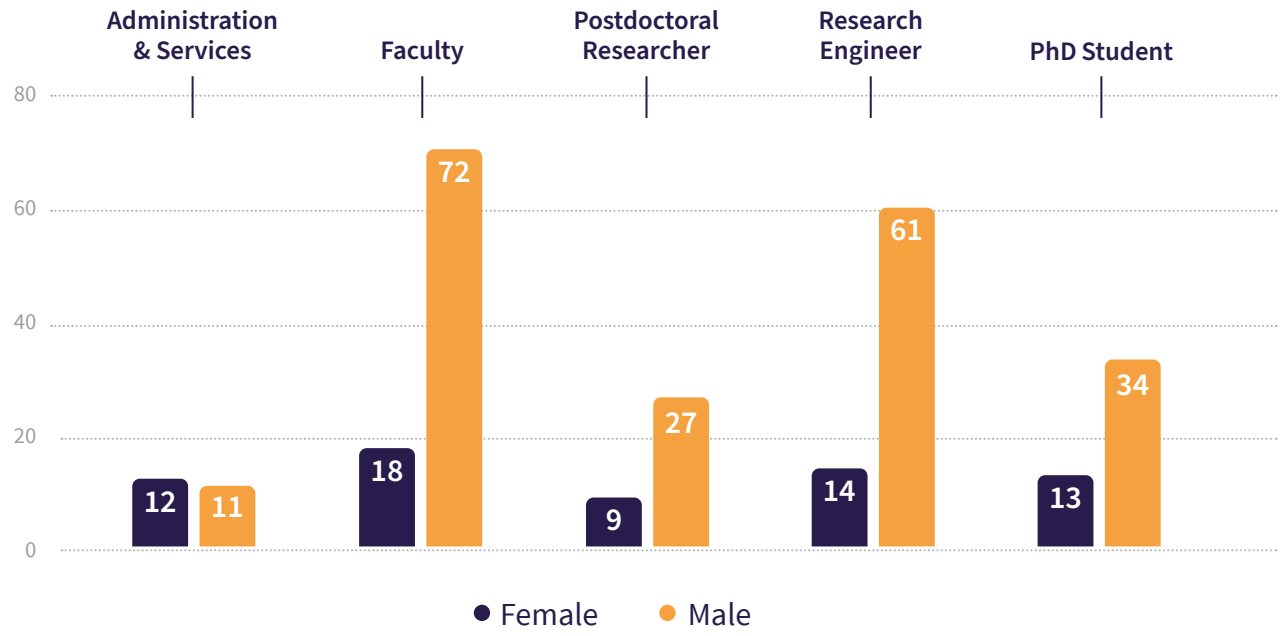


Figure 6

Researchers by role and hiring entity

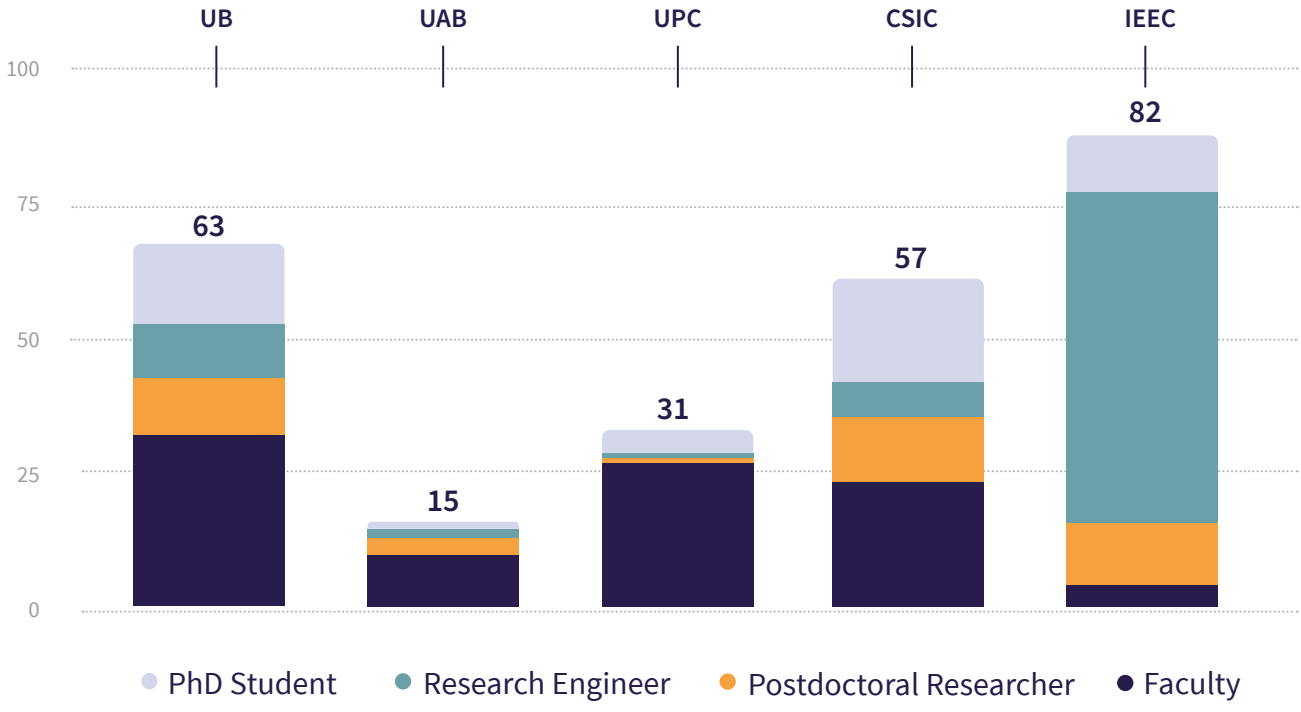


Figure 7

Projects

PROJECTS

The plots and graphs below show the funding secured and managed by the IEEC, including base funding from the competitive projects, non competitive projects and contracts/agreements with industry*.

Income by type of project

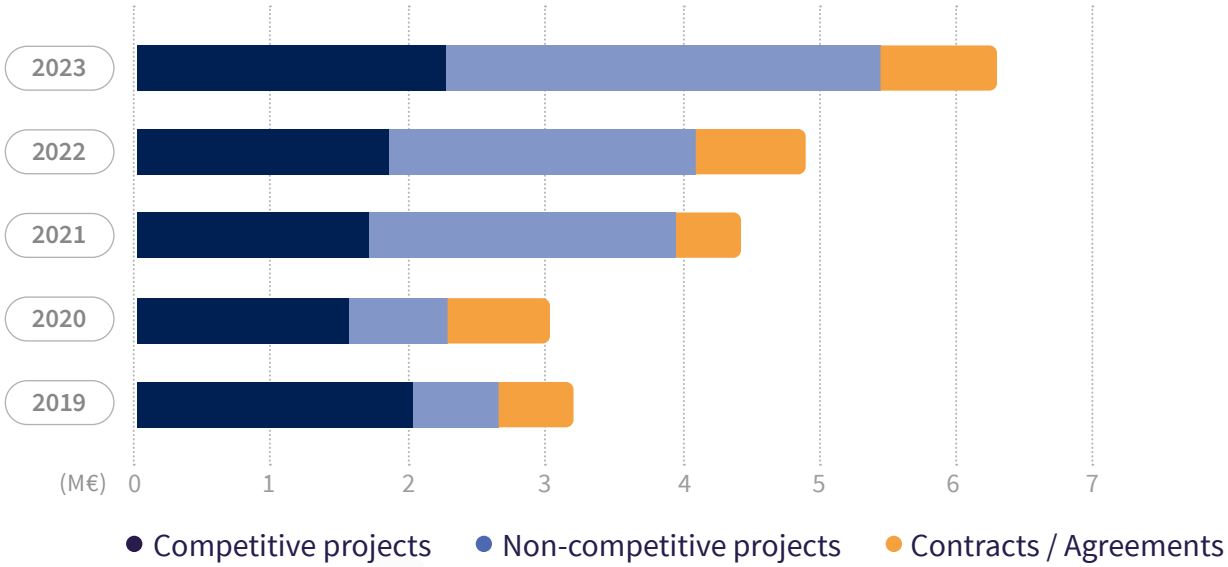


Figure 8

Income by geographical area

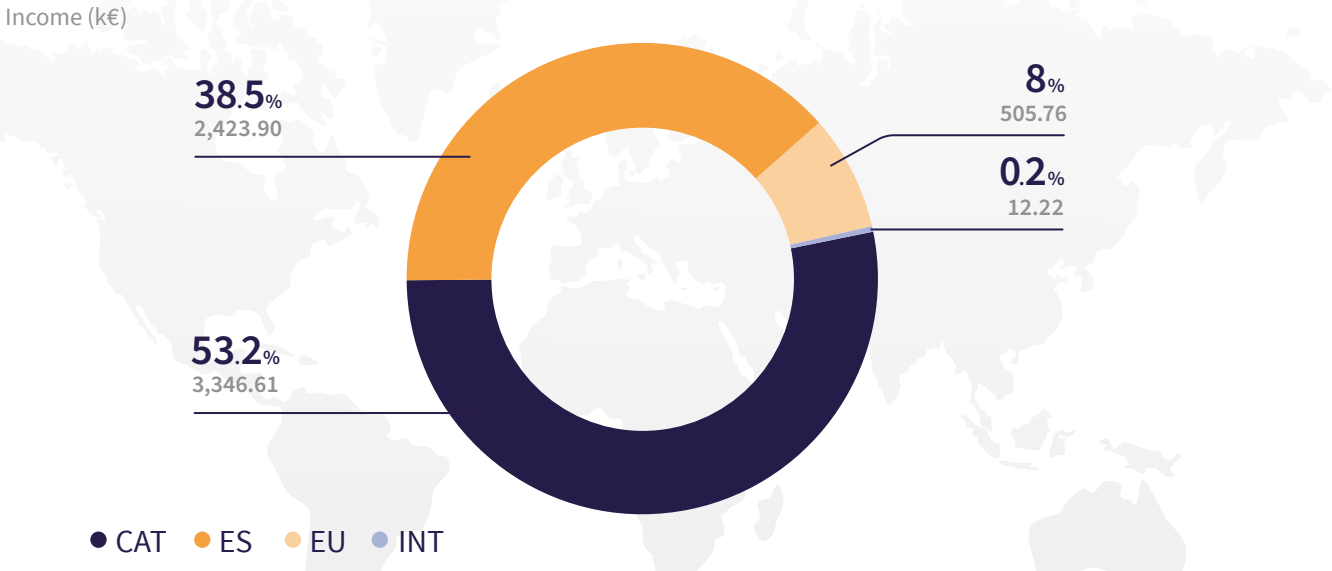


Figure 9

* Provisional economical data pending closure of the 2023 financial year.

Contracts / Agreements	Income (k€)
European public sector	309.4
National public sector	267.2
National industry	211.1
European private sector	59.3
International (non-European)	12.2
TOTAL	**859.2**

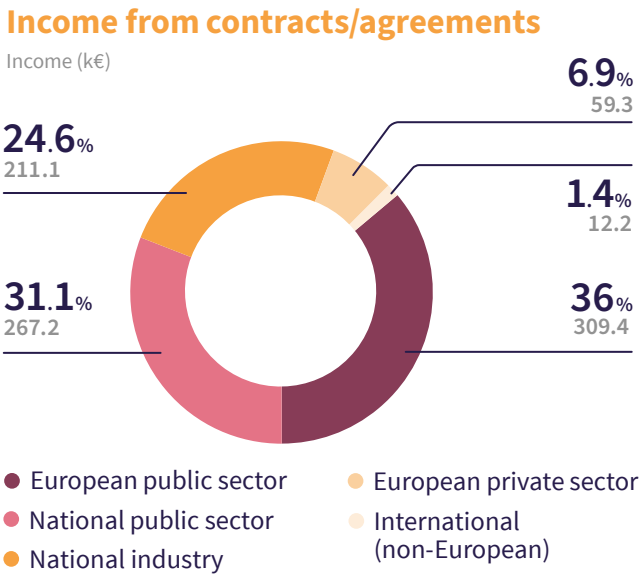


Figure 10

Subsidies	Income (k€)
COMPETITIVE PROJECTS	
AGAUR	171.7
MCIU	1,945.6
EU	137.0
TOTAL	**2,254.3**

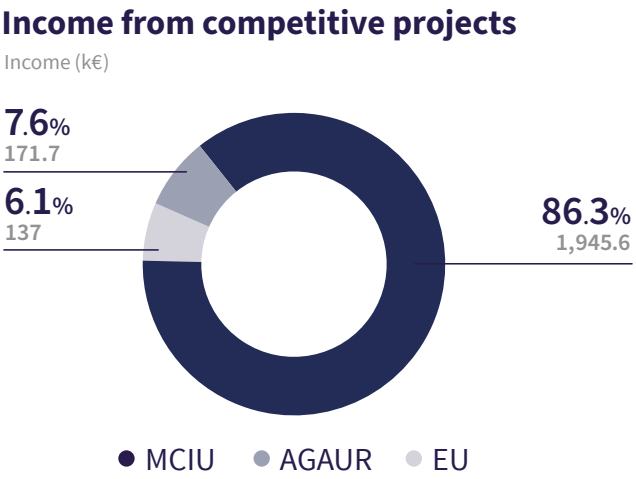


Figure 11

Subsidies	Income (k€)
NON-COMPETITIVE PROJECTS	
NewSpace Strategy	1,810.2
Programme contract	1,132.1
Others	232.6
TOTAL	**3,174.9**

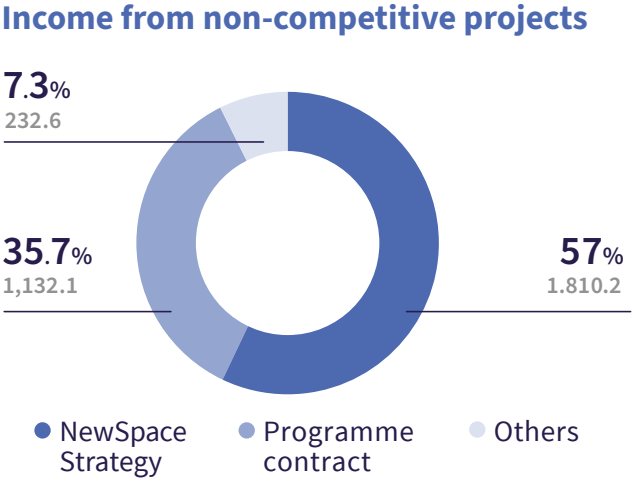


Figure 12

Publications

PUBLICATIONS

The total number of publications authored by the IEEC members is 419*. Hereby there is a graphical summary of the total scientific and technical publications according to the Research Unit, journal quartile, journal, number of authors, and scientific subject. 95.0% of publications authored by the IEEC is distinguished as Open Access (OA) content.

Number of publications by Research Unit

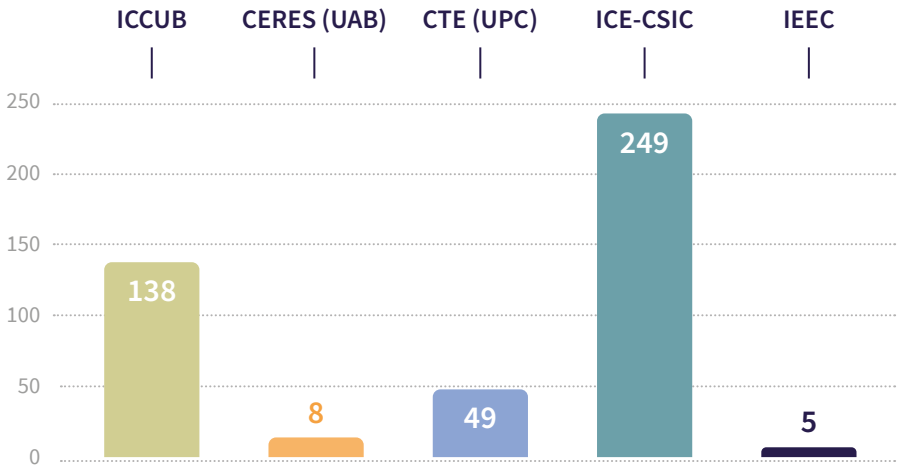


Figure 13

Number of publications by journal quartile

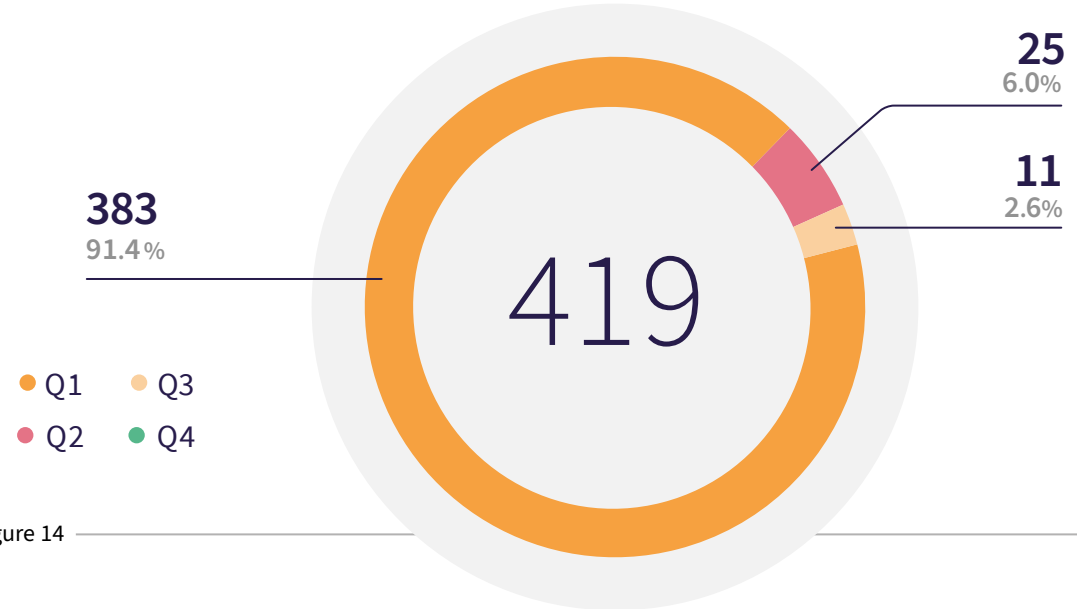


Figure 14

* The total number of publications includes the 16 publications done by authors at the Institute of Applied Computing with Community Code (IAC3) of the University of the Balearic Islands (UIB).

Number of publications by journal

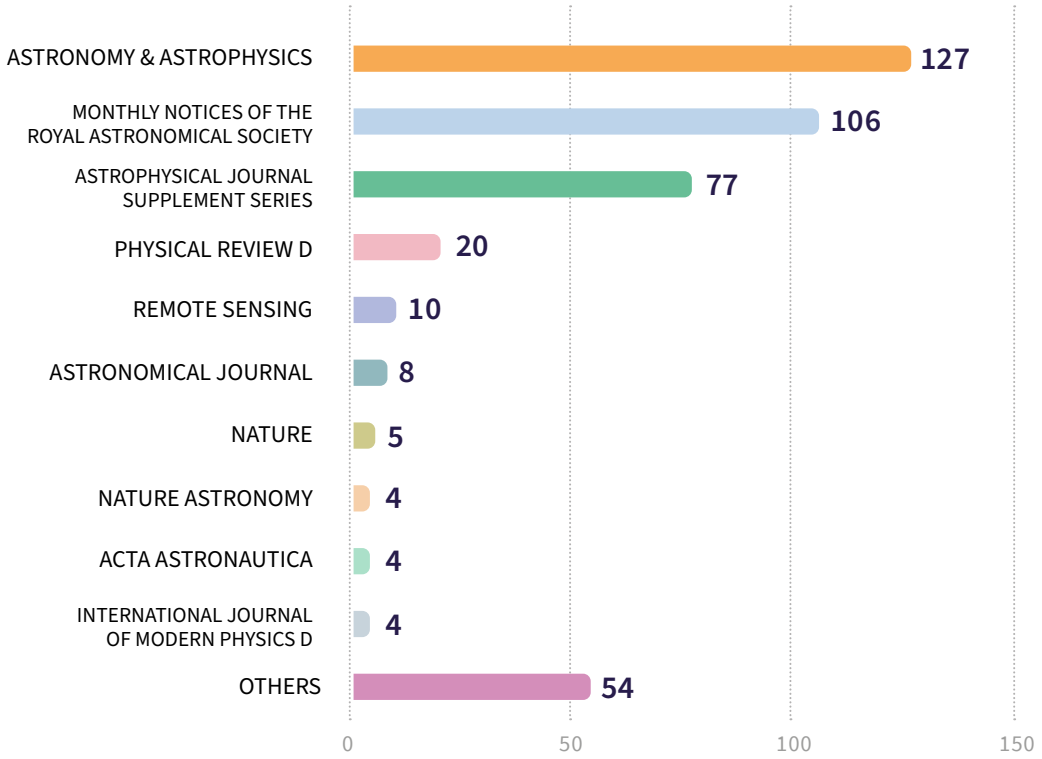


Figure 15

Number of publications according to number of authors

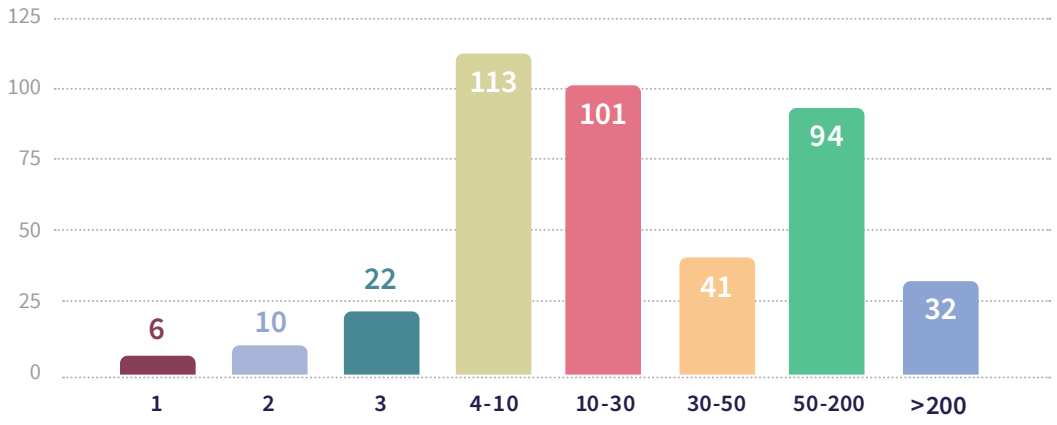


Figure 16

Number of publications by subject

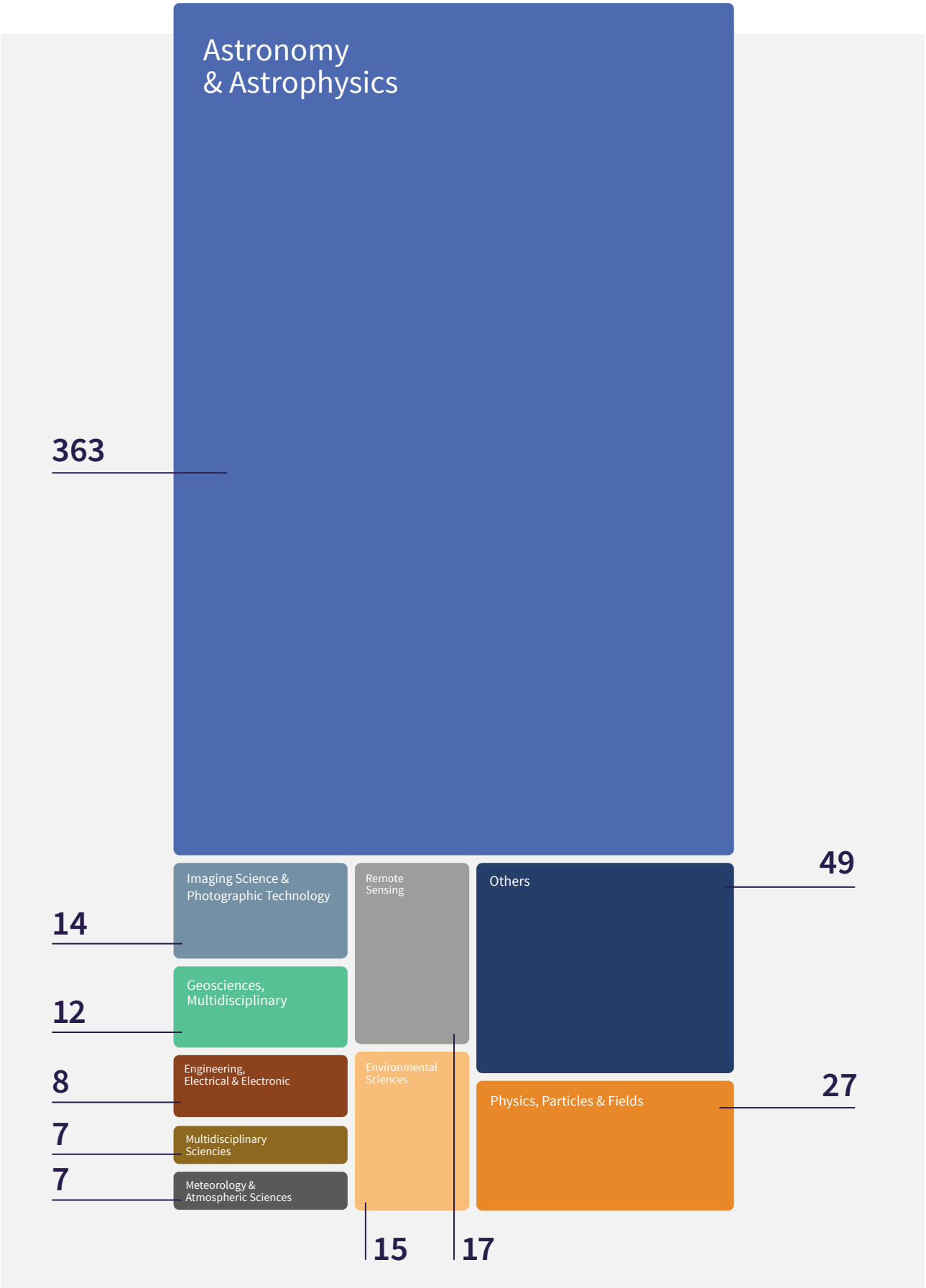


Figure 17

Some publications were collaborations between authors at different IEEC Research Units. These are:

Collaborations	Publications
ICCUB + ICE-CSIC	**19**
ICCUB + CERES (UAB)	**6**
ICE-CSIC + IAC3 (UIB)	**6**
ICE-CSIC + CTE (UPC)	**5**
ICCUB + CTE (UPC)	**3**
ICE-CSIC + IEEC	**3**
ICCUB + IAC3 (UIB)	**3**
CTE (UPC) + IEEC	**1**

Table 3

Productivity	2020	2021	2022	2023
Total number of researchers (including engineers & students)	184	255	227	**226**
Articles in peer-reviewed journals (Source: Web of Science)	436	450	420	**419**
Number of articles per researcher	2.4	1.8	1.8	**1.9**
% of articles in Q1 journals (Source: Web of Science)	87.4	86.6	88.6	**91.4**
PhD Theses	11	15	15	**7**

Table 4

Facilities and Key Projects

Montsec Observatory

A leading infrastructure for astronomical research, technological services, and environment monitoring.

The Montsec Observatory (OdM, montsec.ieec.cat) is a scientific infrastructure that is managed by the IEEC by virtue of an agreement with the Direcció General de Recerca of the Generalitat de Catalunya. It is located at an altitude of 1,570 metres in the Montsec mountain range, 50 km north of the city of Lleida, in the municipality of Sant Esteve de la Sarga (near Àger), in the Catalan pre-Pyrenees. This area is recognised as one of the most suitable on the European continent for astronomical observation, thanks to the combination of weather conditions and the low level of light pollution.

The main goals of the Observatory are to provide tools to carry out cutting-edge research in astronomy and the necessary support to exploit the OdM facilities, to serve as a testbed for the development of new astronomical instrumentation, and to provide space-related services to public institutions and industry. In this context, the largest telescope (the Joan Oró Telescope, TJO), and the AllSky Camera are directly managed by the IEEC. The main feature of the TJO is its robotic operation, so that observations and the decision-making process in the event of incidents are carried out automatically and without human intervention.

The OdM astronomical facilities have yielded important findings in the fields of exoplanets, supernovae and solar system research. Moreover, they have contributed to the tracking of satellites and the monitoring of atmospheric quality in the Montsec area. During 2023 the IEEC achieved various milestones at the OdM. Below, we provide a summary of these.

OdM infrastructures

In 2023, a number of improvements were made to the OdM infrastructures. Several computers were upgraded and their integration into the system was improved by monitoring the hardware performance. The management of the uninterrupted power supply systems was improved to ensure a better handling of the critical hardware in case of power outages or storm alerts. The main software developments in 2023 were focused on the optimisation of the TJO scheduling (ISROCS) and its dynamic response to observing requests during the night, as well as on the improvements on the sensor redundancy management by the Weather Control System (WCS). A new flat-field illuminated screen was installed at the dome of the TJO in order to allow for a better management of the calibration process of the TJO scientific images, and its functionality is expected to be implemented in the control system (OCS) in early 2024. Finally, a new control system was designed for the Differential Image Motion Monitor (DIMM), together with some hardware improvements, with the aim of starting continuous and fully autonomous seeing monitoring in early 2024.

Also at the OdM, the GNSS station and accelerometer of the Institut Cartogràfic i Geològic de Catalunya was built and started operations. Additionally, an agreement was signed with INGESCO for the installation of an antenna of their new network for storms and lightning monitoring, with the aim of including the resulting data to the WCS of the observatory once the network is fully functional. In parallel, civil works were carried out at the main building of the TJO to repair some of its main external walls, and the basement of the electric transforming station was improved, together with its ground connections, in order to ensure its reliability for the next years.

Science with the TJO

The TJO is a fully-robotic 0.8 m telescope used for different applications, including multiple astrophysics fields, and also Space Surveillance and Tracking (SST) activities. This telescope can observe with two different instruments, including an imaging camera (LAIA) and a spectrograph (ARES). During 2023 LAIA suffered a series of repairs and for most of the year the previous MEIA2 camera was used.

The TJO provides useful data that is distributed through the OdM web portal and also through the node of the Spanish Virtual Observatory (SVO). In 2023, the SVO was updated to include all the public raw images of the TJO with a total of over 613,000 images, obtained during 3,200 different nights since 2013. The TJO offered around 70% of its available time in 2023 to the international astronomical community, with a fraction of requested over available telescope time of 1.1. At the end of 2023, the OdM had 209 registered users on the Management for Users in ROCS (MUR, mur.ieec.cat), which represents approximately a 5% increase in the number of registered users compared to 2022.

Image 2: General view of the TJO building at the OdM. Credits: IEEC/OdM

CONTACT PERSON

Kike Herrero,
Director of the Montsec Observatory
eherrero@ieec.cat

During 2023, the telescope participated in different scientific projects, including the study of Solar System objects, monitoring of exoplanet transits, characterisation of M dwarf stellar activity, study of eclipsing binaries, monitoring of novae, detailed studies of white dwarfs or newly discovered black hole X-ray binaries, light curves of type Ia and type Ic supernovae, Gaia transients such as the ones producing microlensing events, and monitoring of gamma-ray emitting blazars.

The number of refereed publications has notably increased in the past two years (Image 3, up) due to the new observation programmes started. Also, the amount of requested and delivered science time with the TJO has been significantly increasing since 2016 (Image 3, down), and it is now equivalent to the total night time available with good weather.

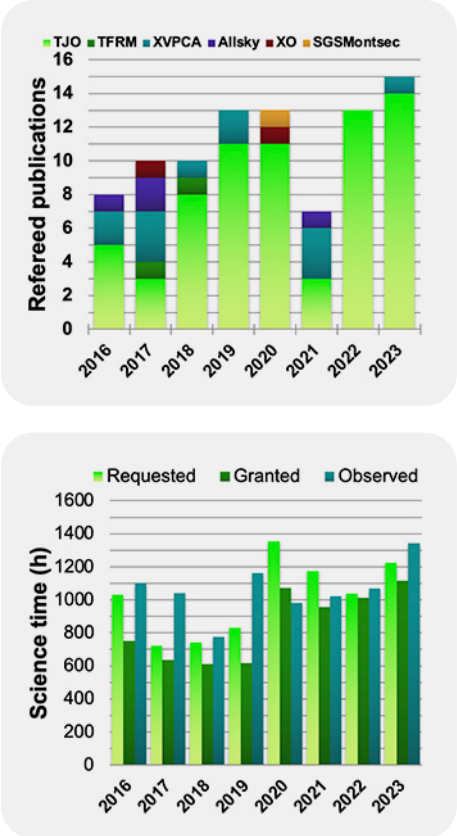


Image 3: Number of refereed publications per year from the facilities at OdM during the last 8 years (up). Total amount of science time requested, granted and observed with the TJO (down). Credits: IEEC/OdM

PhotSat

Cubesat satellite to track the 10 million brightest stars in the sky developed entirely by the IEEC and its academic and industrial ecosystem.

PhotSat is a project coordinated by the IEEC that involves the development and construction of a satellite to track the 10 million brightest stars in the sky for at least two years. Through an ingenious system of rotating mirrors, the satellite's two telescopes will take measurements of almost the entire sky every two days. These telescopes will have a diameter of about 10 cm and will be optimised for observing from ultraviolet to visible light. The measurements, which will be particularly accurate for bright stars, will be useful for a variety of scientific programmes, including the search for exoplanets, characterisation of stars and observation of transient phenomena, among many others.

PhotSat will have a CubeSat format with a planned size of 12 units (each unit is a cube with a side of 10 cm) and a total weight of between 10 and 20 kg. The satellite will orbit the Earth in a low orbit (LEO), at an altitude of about 500 km, and will communicate and download the data it produces via the Sant Esteve de la Sarga Teleport at the Montsec Observatory.

During 2023, the PhotSat team has been working on the initial design of the different systems and components of the scientific payload, carrying out analysis and developing a prototype of the optomechanical subsystem as well as simulators for testing and analysis. The aim is to reach a Preliminary Design Review (PDR) by early 2024.

Image 4: Render of the current design of the PhotSat satellite. Credit: IEEC

Furthermore, after several meetings and conversations with various groups interested in participating in the project, the mission's consortium has been established. Several academic groups belonging to the UB, UAB and UPC have agreed to participate in the mission's development. Their experience and dedication are key elements for the success of this project.

PhotSat will be the first scientific satellite developed entirely (from the design phase to operations) by the IEEC and its academic and industrial ecosystem, which will generate valuable experience around NewSpace technologies and will contribute to enhance public-private collaboration.

To finance the project, 3.6 million euros have been allocated to the IEEC from the Astrophysics and High-Energy Physics Complementary Plan of the Spanish Government. These plans are state collaborations with the autonomous regions in R&D&I actions to channel European funds from the Recovery and Resilience Mechanism, a key part of the NextGenerationEU programme.

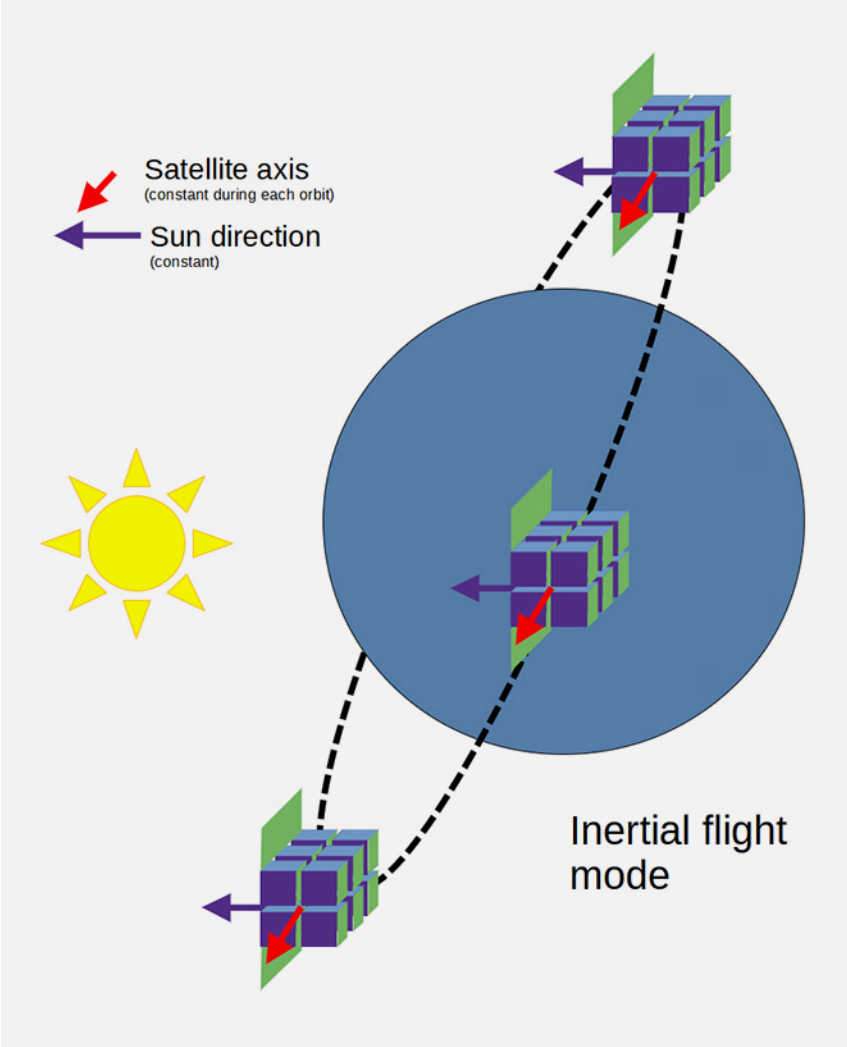


Image 5: PhotSat low Earth orbit (helio synchronous, 500 km above surface). Credit: IEEC

CONTACT PERSONS

Ignasi Esteva,
Research Engineer
esteva@ieec.cat

Carles Sierra,
Research Engineer
sierra@ieec.cat

Ariel

The mission will analyse the atmospheres of a large sample of transiting exoplanets using transmission spectroscopy.

Ariel (Atmospheric Remote-sensing Exoplanet Large-survey) is the fourth medium (or 'M-class') mission of the European Space Agency (ESA) that was adopted in 2020 and is expected to be launched in 2029.

It consists of a 1 metre class telescope equipped with low-resolution spectrographs that will cover the wavelength range from 1.1 μm to 7.8 μm. Ariel will study a complete sample of transiting exoplanets by means of transmission spectroscopy. This means that it will measure the spectra of planets through the follow-up of their transit in front of their host stars or the occultations behind them. This type of observation provides a wealth of information about the atmosphere of the planets such as the chemical composition, the vertical pressure-temperature profile, the dayside-nightside temperature difference, the atmosphere circulation patterns, and the presence of clouds for instance. The goal of this survey, which will characterise a large number of exoplanet atmospheres during its 4 years lifetime, is answering the first of the four ambitious topics listed in the ESA's Cosmic Vision: "What are the conditions for planet formation and the emergence of life?"

The Ariel mission payload is developed by a consortium of more than 70 institutes from 17 countries. The IEEC is one of the co-PI institutes (co-PI: Ribas) and leads the Spanish contribution (PI: Ribas; National Project Manager: Colomé), which also includes the Instituto de Astrofísica de Canarias (IAC) and the Universidad Politécnica de Madrid (UPM). The IEEC, through researchers at the ICE-CSIC and ICCUB, participates in two aspects of the mission, one eminently scientific and the other of technological nature. Regarding the science part, our work basically consists in studying the effects of stellar intrinsic variations, known as stellar activity, on the spectra of planetary atmospheres. We are developing methods to correct out such variability and thus keep Ariel's data free of any bias. In the past years, we suggested the use of complementary observations for this purpose (see Rosich et al. 2020). During 2023, we have conducted an observational campaign to apply this methodology to an interesting exoplanet in coordination with James Webb Space Telescope (JWST) observations. We plan to use this system as a test case to implement the potential of Machine Learning algorithms to this methodology. This will be developed as a PhD.

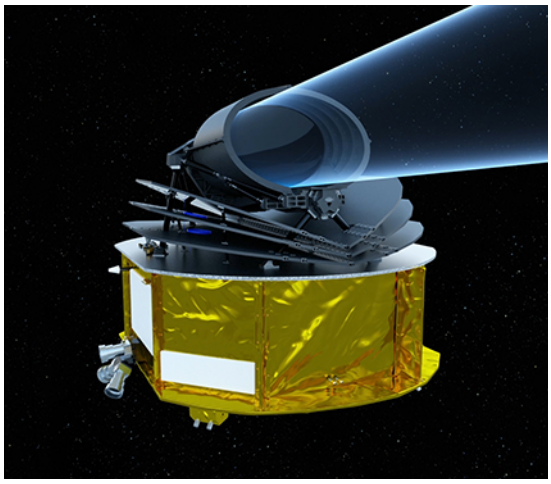


Image 6: Depiction of the Ariel telescope gathering data from distant exoplanets. Credits: Ariel Consortium

With regard to technology, the IEEC is responsible for the design, implementation, assembly and verification of the Telescope Control Unit (TCU). Its purpose is high precision measurement of the cryogenic temperatures of the telescope, and control of the secondary mirror (M2) refocusing mechanism under operation from ground. During last year the TCU team has achieved several key milestones on the progress of the unit such as successfully passing the instrument Preliminary Design Review. This milestone approved the current unit design and gave the go ahead for the start of the purchase, build and test of the first units next year. The progress made on the mechanical design of the TCU has been key in consolidating the final

design of the unit. To prove the mechanical design and the interfaces of the unit to the platform, the team manufactured and delivered a structural model to Airbus to undergo mechanical and vibration tests. The design of the different elements that conforms the TCU, such as the power supply unit (PSU), Control and Thermal Sensing (CTS), and the Secondary Mirror Driver (M2MD) have been fully developed and first prototypes are being manufactured to perform interface testing between the TCU and the rest of the teams from the consortium.

The IEEC is also in charge of providing a scheduling tool to automatically plan the observations as part of the Ground Segment of the Ariel mission, the so-called Ariel Long Term Planning Tool (LTPT). This is a key subsystem of the Ground Segment due to the complexity of planning the follow-up of about 1,000 planetary systems whose transits need to be observed up to several times in order to pile them up and improve the signal-to-noise ratio. A prototype of the LTPT tool was designed (Morales et al. 2022). In 2023 we have designed a new optimization algorithm (as part of a PhD thesis) to improve the efficiency of observational plans (Nakhjiri et al. 2023), and we have started the formal development of the software that we will deliver to ESA. High-level requirements related to the LTPT have been identified in preparation for the Ground Segment Requirements Review (May 2024) and a first release of the software was sent to ESA for product assurance evaluation.

References:

- Morales, J.C., Nakhjiri, N., Colomé, J., Ribas, I., García, E., Moreno, D., Vilardell, F. Experimental Astronomy, 53, 807-829 (2022)
- Nakhjiri, N., Salamó, M., Sànchez-Marrè, M., Morales, J.C. Engineering Applications of Artificial Intelligence, 126, 106856 (2023)
- Rosich, A., Herrero, E., Mallonn, M., Ribas, I., Morales, J. C., Perger, M., Anglada-Escudé, G., Granzer, T. A&A, 641, A82 (2020)

CONTACT PERSONS

Ignasi Ribas,
Faculty
iribas@ieec.cat

José M. Gómez
Faculty
jmgomez@ieec.cat

Euclid

Understanding dark energy and dark matter by studying the expansion rate of the Universe and the growth of structure.

Euclid is a European Space Agency (ESA) cosmology mission to study the accelerated expansion of the universe, also known as dark energy. It contains two instruments: a visible imager and a near-infrared spectrophotometer. Euclid has been designed to study the expansion rate of the Universe and the growth of structure using weak lensing and galaxy clustering as main cosmological probes. It will carry out a survey covering 15000 deg2, one third of the sky, taking high resolution images and slitless spectroscopy of millions of galaxies. The IEEC has leadership roles and visibility in the mission: it belongs to the ESA Euclid Science Team, it is part of the Euclid Consortium Board, it leads the simulation effort, develops software and has contributed to hardware.

During the first part of 2023 Euclid passed its last tests on ground and was shipped in April to Cape Canaveral, Florida. Two weeks prior to launch, the Euclid Consortium held its annual meeting in Copenhagen. On 1 July 2023, Euclid was successfully launched with a Falcon 9 rocket from SpaceX. The launch was very efficient and Euclid was injected into its orbit without the need for major manoeuvre corrections. In a month, Euclid reached its target orbit around the Lagrange L2 point. In the first month, Euclid underwent commissioning making sure that the instruments were functional and adjusting the telescope focus. At the end of July, Euclid released a few demonstration images taken during commissioning to showcase the potential of Euclid. In August, Euclid started its Performance Verification (PV) phase. In mid August, it returned to commissioning to solve some problems found with the Fine Guide Sensor determination of the telescope guiding. At the end of September the PV phase was re-started, acquiring the data needed to calibrate the mission. In November, Euclid released to the world the Early Release Observations (EROs) of special observations taken during the PV phase. These EROs included observations from galaxy clusters to gaseous nebulae demonstrating the capabilities of Euclid to cover a large field with exquisite image resolution. On 3 December, the Euclid survey officially started taking data. The first observations taken were designed to measure the Wave Front Error and calibrate the system Point Spread Function (PSF).

On our side, we continued to lead the Cosmological Simulations working Group and the Simulations Organisation Unit of the Science Ground Segment. We have been working on improvements to the Flagship simulation and in the writing of the paper describing the mock galaxy catalogue. Together with the Port d'Informació Científica (PIC), the IEEC group at the Institute of Space Sciences (ICE-CSIC) has produced the simulations used in cycles 16 and 19 of the Science Ground Segment and all the simulations required to prepare and support the PV phase of the mission. The paper describing the Science Challenge 8 simulations has been submitted for publication. During the year, we have attended the Euclid Science team meetings, where the main focus was the monitoring of the latest stages of preparation for the launch and the subsequent check of the satellite and instrument performances. We have also organised the cosmological simulations science working group meeting in November. During the last months of the year, we also prepared for the Mission Commissioning Readiness Review that was scheduled for January 2024.

Image 7: On 1 July 2023, Euclid was successfully launched with a Falcon 9 rocket from SpaceX. Credit: SpaceX

CONTACT PERSONS

Francisco Castander,
Faculty
fjc@ieec.cat

Pablo Fosalba,
Faculty
fosalba@ieec.cat

Gaia

The most accurate three-dimensional map of the Milky Way, with almost two billion stars, galaxies, quasars and Solar System objects.

19 December 2023 marked ten years since the launch of the European Space Agency's Gaia satellite. The mission has already more than achieved the goal of creating the most accurate and complete map of the Milky Way to date. Since its launch, it has accumulated more than 3,400 days of nominal operations and has already delivered 5 data releases to the international community (2016, 2018, 2020, 2022 and 2023). Gaia is demonstrating its great scientific potential, with more than 10,000 articles published in such diverse and transversal fields of astronomy as galactic astronomy, stellar physics, exoplanets, the solar system, quasars and fundamental physics. The articles of the consortium dedicated to the last release, the Focused Product Release, which cover several types of objects of special relevance, should be highlighted here.

Image 8: This image shows the stellar density of the Large and Small Magellanic Clouds (LMC and SMC), two dwarf galaxies that orbit the Milky Way, as seen by Gaia. It is composed of red, green and blue layers, which trace mostly the older, intermediate age, and younger stars respectively. Credits: ESA/Gaia/DPAC; CC BY-SA 3.0 IGO. Acknowledgement: L. Chemin; X. Luri et al (2020)

The current Gaia archive, with open access to the entire community since day one, contains the position and motion of more than 1.8 billion stars in the Milky Way, including also more than 10 million variable stars and almost a million binary systems. The mission has also catalogued 3 million galaxy candidates and 2 million quasar candidates, among others, and has revolutionised knowledge of the Solar System by precisely tracking more than 158,000 objects, including near-Earth asteroids, those in the main belt, and trans-Neptunian objects. In addition, the spectroscopic data provided by the mission is unprecedented in the history of astronomy, both for the amount of data published, more than 200 million spectra, and for the unique calibration process for the whole sky. The astrometric, photometric and spectroscopic precision achieved so far, with only data from the first 34 months of the mission having been published, has completely transformed our previous view of the origin and evolution of our galaxy. And not only that, it is also transforming the day-to-day research in galactic and stellar astronomy, raising the need to use new methodologies and new tools to advance present and future studies.

Gaia will continue to observe until the first quarter of 2025, when the gas that allows the satellite to maintain its uniform rotation and precise pointing will run out. Data processing will continue for a few more years, and is expected to increase greatly in complexity and accuracy. The mission's final catalogue is not expected to be published until well into the 2030s, with a sixth release due in 2025.

ICCUB-IEEC teams have been fully involved in the mission since it began to be designed, now more than 25 years ago. They have participated in the development of critical parts of the mission such as data processing, the design of the photometric system and the validation of each of the catalogues that have been published. It has been thanks to the experience acquired during all these years that the scientific team has been and continues to be a pioneer in the tasks of scientific exploitation and publication of new discoveries.

CONTACT PERSONS

Lola Balaguer,
Faculty
lbalaguer@ieec.cat

Xavier Luri,
Faculty
luri@ieec.cat

LISA

The first observatory of gravitational waves in space.

The Laser Interferometer Space Antenna (LISA) is a Large-class mission of the European Space Agency (ESA), in collaboration with the US National Aeronautics and Space Administration (NASA), to put in space an all-sky monitor that will offer a wide view of a dynamic cosmos using low-frequency gravitational waves. More specifically, LISA is a triangular constellation of three spacecraft which will follow the Earth in its orbit around the Sun. They are separated by 2.5 million km, and connected by laser beams that monitor the relative distance between free-falling test masses (obtaining in this way the two independent gravitational-wave polarizations simultaneously). LISA will provide the closest ever view of the infant Universe at TeV energy scales, has known sources in the form of verification binaries in the Milky Way (ultracompact binaries), and can probe the entire Universe, from its smallest scales near the horizons of black holes, all the way to cosmological scales. Then, LISA is expected to make revolutionary discoveries in Astrophysics, Cosmology and Fundamental Physics.

The Gravitational Astronomy-LISA Group of the Institute of Space Sciences (ICE-CSIC) leads the Spanish contribution to the LISA mission (in collaboration with the UPC-IEEC and UB-IEEC groups), the Science Diagnostics Subsystem (SDS), consisting of a series of sensors and actuators of high precision and unprecedented stability, together with all the associated electronics, that will provide essential information about the environment of the LISA measurement system. Diagnostics are: Thermal (sensors and thermal actuators), Magnetic (magnetometers, coils and electromagnetic antenna), Radiation (radiation monitor). On the science exploitation side, the LISA-IEEC collaboration is also leading the development of the Spanish Data Distributed Center together with a so-called global fit pipeline, which will be used to create a catalogue of gravitational-wave sources from the LISA Data stream. It actively participates in several working groups of the LISA international consortium, from astrophysics to data analysis developments.

The LISA-IEEC collaboration has contributed to the preparation for the Mission Adoption Review (MAR), scheduled in January 2024, by providing the necessary tests and reports for the SDS—after that, LISA would enter the implementation phase with an expected launch date in 2035. Moreover, during 2023, the group has successfully concluded the LISA Enhanced Temperature Subsystem (LETS) activity. LETS was an ESA contract to develop a prototype for the temperature diagnostics subsystem for LISA, which has been already manufactured and tested. This prototype, currently in usage at ICE-CSIC labs, achieves high precision performances in temperature sensing (~microkelvin resolution), and will be used for the forthcoming phases of LISA implementation and testing. Members of the collaboration have also contributed, as authors, to the LISA Definition Study Report (the so-called Red Book, which was made public in February 2024). They have also supported the Spanish delegation in the definition of the multilateral agreement for LISA, where the Spanish contribution is defined.

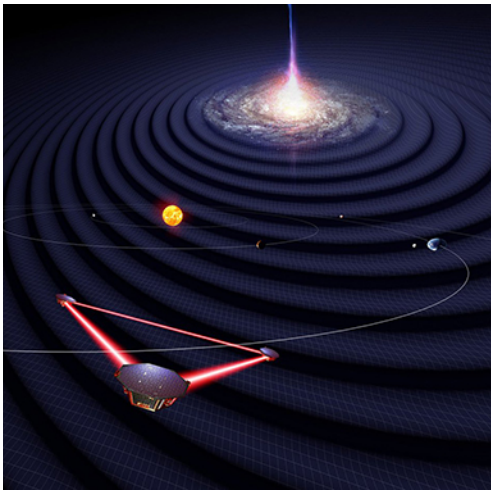


Image 9: Artistic representation of LISA (the ESA-L3 mission). The constellation of three spacecraft is shown following a heliocentric orbit around the Sun following the Earth. In the background, a representation of the emission of gravitational waves by a binary system of supermassive black holes. Credit: University of Florida / Simon Barke (CC BY 4.0)

CONTACT PERSONS

Carlos Sopuerta,
Faculty
sopuerta@ieec.cat

Miquel Nofrarias,
Faculty
nofrarias@ieec.cat

Plato

The mission will search for and characterise a large number of planetary systems and their host stars, particularly Sun-Earth twin systems.

Plato (PLAnetary Transits and Oscillations of stars) is the next medium-class mission of the European Space Agency (ESA) to be launched in 2026. The payload of this mission is composed of 26 cameras that will be staring continuously to the stars from the L2 Lagrangian point with the goal of detecting the tiny light drop caused by exoplanets transiting in front of them. Plato is expected to discover thousands of planetary systems hosting rocky and gas giant planets that will provide insights into the formation and evolution of such systems. But the mission is particularly designed to look for Sun-Earth twin systems, that is, rocky planets in the habitable zone of solar-type stars, i.e. at the range of distances in which liquid water can be sustained on the surface of the planet. Finding and characterising such planets is the first step towards the long quest objective of finding life beyond the Earth. Furthermore, Plato is also expected to provide a wealth of information about the host star itself through the analysis of their seismology from high-frequency photometric variability, from which fundamental parameters such as the mass and the age of stars can be inferred.

The exoplanets detected by Plato by means of the transit method will have to be confirmed with additional observations in order to discard false positive scenarios. Besides, such observations will as well provide a measurement of the mass of the exoplanet, which in combination with the radius determined from the transit, reveals the bulk properties such as its density. A Ground-based Observations Program (GOP) is put in place to coordinate all these observations, that can be as different as photometric follow-up of the stars to confirm the transit detection, high-contrast imaging to look for background contaminant stars, and high-precision spectroscopic follow-up from which the radial velocity of the stars, and hence the mass of the exoplanets, is derived. Organising and planning all these observations for thousands of planetary candidates to be carried out at different ground-based facilities is a challenge that the IEEC team has undertaken given our expertise in scheduling systems within the framework of the STARS project.

Image 10: Numerous exoplanet systems await discovery by the Plato space probe. Credits: ESA

Different IEEC units are in charge of developing the system that will coordinate the GOP operations. We are leading different work packages. In particular, those devoted to the data handling and the communications between subsystems and databases (ICCUB), and the observations scheduling (ICE-CSIC). During 2023, we have been working on the flow-down of requirements from the Plato science plan, and the design of the overall infrastructure in preparation for the review that will take place during the second quarter of 2024. The design consists of a GOP Data Center (at the IEEC facilities) hosting a repository of data and an orchestrator software in charge of coordinating the communications between the Plato Data Center (PDC), which will provide the properties of the stars and exoplanet candidates, and the scheduling system. The latter will be in charge of distributing the different observations to be carried out between the observatories in an efficient manner. To do so, we are adapting the STARS scheduling and Artificial Intelligence optimization algorithms. Besides, we are developing a Graphical User Interface that will be tailored to the Plato needs in order to monitor the GOP operations.

In addition to the GOP, the IEEC is helping to better define the science case of the mission and prepare the data analysis tools. We have been contributing to the work packages on Stellar Activity and Rotation and Spot Models and are responsible for the production of the libraries of stellar models that will be used by Plato to determine the fundamental properties of stars in its core program.

CONTACT PERSONS

Juan C. Morales,
Postdoctoral Researcher
morales@ieec.cat

Jordi Portell,
Research Engineer
portell@ieec.cat

NewSpace Strategy

NEWSPACE STRATEGY

The new space economy (or NewSpace) represents a disruptive leap in the use of space thanks to the deployment of small satellites (nanosatellites), based on advanced industrial and digital technologies, more economical and faster to develop.

Nanosatellites, defined from the CubeSat standard (a cube 10 cm on a side), have become the ideal platforms for balancing satellite performance and capabilities with the cost of production, launch and operations. These satellites are usually placed in low-Earth orbits (LEO), located between 200 and 1200 km from the Earth's surface.

NewSpace is also characterised by the commercial approach to space infrastructures, with private industry and public and private users being the main recipients of the technologies, products and services developed. The lower cost, the shorter development time to reach the market and the more agile and less risk averse innovation processes make NewSpace an important change in the space sector and represent an opportunity for new players to enter, a democratisation of access and use of space, and cause a huge impact on the services users receive. It offers a set of digital services with a strong capacity for innovation and generates a new market, a new economy with great growth and open to the participation of start-ups, SMEs and large companies, as well as public entities looking for new opportunities in the space sector.

This new space economy makes available to new sectors the use and exploitation of space platforms for a wide variety of applications, such as Earth observation, navigation and telecommunications, and scientific and technological research. These are new applications that allow better management of the territory and infrastructures, the measurement and mitigation of the effects of climate change and having communications coverage, among many others.

The NewSpace sector has consolidated worldwide, with thousands of nanosatellites in orbit and with enormous growth compared to the launches carried out in recent decades.

NewSpace Strategy of Catalonia

In October 2020, the Government of Catalonia approved the NewSpace Strategy with the aim of taking advantage of the opportunity of this paradigm shift for the space sector and promoting its growth based on the solid existing capabilities of the space and digital sectors.

The IEEC, the i2CAT Foundation and the Cartographic and Geological Institute of Catalonia (ICGC)—key institutions for the promotion of the space sector, advanced digital technologies and services based on geospatial data, respectively—participate in the definition and deployment of the strategy.

Catalonia has infrastructure, knowledge and technological background and is a relevant player in the field of NewSpace, with substantial experience in research and innovation, mission launch, design of payloads, ground facilities, space telecommunications, as well as in commercial activity based on the exploitation of satellite data. In addition, it has a first-level digital ecosystem that contributes decisively to the impetus of NewSpace, thanks to the synergy with areas of knowledge such as artificial intelligence, cyber security, advanced electronics for sensors and computers, 3D printing and additive manufacturing, secure communications and new generation mobile communications (5G and IoT), among others.

NEWSPACE STRATEGY

Area for the Promotion of the Space Sector of Catalonia

The IEEC hosts the Area for the Promotion of the Space Sector of Catalonia (APEC) within its structure. The APEC is, by order of the Government of Catalonia, the administrative structure of reference to deploy the satellite policy and properly manage the activity of the space sector in Catalonia, as foreseen in the NewSpace Strategy.

The APEC contributes to the various pillars of the Strategy and carries out activities to promote R&D&I, retain talent, build key infrastructures both in space and on land, and develop services and applications aimed at administration and industrial sectors. It aims to grow the ecosystem by strengthening national capacities in the medium and long term, and promoting international collaboration, always maintaining the entity's commitment to the criteria of social responsibility.

The APEC coordinates its activities with the Government of Catalonia and the other entities promoting the NewSpace Strategy, ICGC and i2Cat, and has been assigned, among others, the following functions:

- Developing the representativeness and promotion activities of the sector both nationally and internationally.
- Acting as a single window to facilitate access to the space sector for companies and entities by reducing administrative barriers and assisting in administrative and legal processes.
- Defining and executing support programmes for the space sector ecosystem,both in the field of research and innovation, and in the creation and growth of companies.
- Creating the necessary facilities and infrastructure and with the appropriate funding for their implementation and operational maintenance.
- Promoting talent, both in its creation and in attraction and retention.
- Creating social awareness of the importance of the space sector due to its impact on improving people's lives and the productive and social economy.

NewSpace activities developed at the APEC

The APEC structure is composed of three offices (Infrastructures, Services and Industrial Promotion, and Development and Innovation) dedicated to the definition and planning, execution and supervision and, finally, analysis of the actions associated with the aforementioned functions. This structure was consolidated in 2023 with the addition of new professionals and now has a total of 15 people, most of whom have an engineering profile and develop functions of specialised management in the space sector and space technology systems engineering.

The functions of the APEC are carried out through a set of activities in different areas, all of which are intended to achieve the expected impact on the growth of the public and private Catalan ecosystem dedicated to NewSpace technologies.

The objectives achieved during 2023 show a great progression in relation to those of previous years, and since the creation of the APEC in the IEEC. In general terms, progress has been made in consolidating collaboration with the productive sector and in different areas of the public sector (administration, academia, research) at national level, in the positioning in the state and international arenas and in the long-term positioning.

Regulatory scope and representativeness

With the aim of defining and promoting satellite policy and representing and promoting the New Space sector in Catalonia, the APEC works on the national and international cooperation strategy and advises the Generalitat Administration in policies to stimulate the sector. Within this framework, meetings were held in 2023 with representatives of state and regional bodies that have made it possible to identify opportunities and promote the capabilities of the ecosystem. In particular, initiatives such as PERTE Aeroespacial have been followed up with the Spanish Space Agency, which have made it possible to promote the impact on the ecosystem. Similarly, the interaction with the European Commission, EUSPA and the European Space Agency (ESA) has also been maintained for issues related with programmes such as IRIS2, Copernicus (e.g., Contributing Missions), CASSINI (e.g., Hackathons), scale -up (e.g., ESA-BIC, PhiLab), Zero Debris Charter, BASS, etc.

During 2023, the APEC-IEEC Advisory Committee has also been established. This committee is made up of representatives of bodies of the Generalitat administration, public entities and people from private entities. The aim of this committee is to be able to collect the vision of entities that provide valuable experience from the different areas of the NewSpace value chain and, at the same time, from the different perspectives that make up the sector. This committee will assess the development of IEEC actions, as well as the creation and coordination of working groups created ad hoc to cover specific areas.

Services and Industrial Promotion: ecosystem, international cooperation

The APEC carries out a series of services intended to support the ecosystem in Catalonia. The ecosystem largely participates in the NewSpace community of the Digital Catalonia Alliance (DCA), an entity managed by the i2cat Foundation, and is made up of more than 90 members. The IEEC and the DCA coordinate efforts in order to maximise the impact of initiatives in the digital sector and those in the space sector, with the benefit that this entails for the growth of the Catalan NewSpace sector.

The APEC provides specialised support to companies and entities in the sector, both in technical, legislative and market areas. At the same time, it identifies and manages participation in national, state and international consortia to carry out cooperation promotion tasks that allow the ecosystem to be positioned, take advantage of funding opportunities and attract relevant actors at an international level. In addition, it carries out actions for promotion, such as attendance at fairs and congresses of the space sector, and the organisation of events. Finally, the APEC also collaborates to encourage the use of applications and services provided by NewSpace technologies from the implementation of pre-commercial solutions based on Earth observation and navigation.

During 2023, the APEC has successfully achieved different actions: it has supported more than 20 companies and entities in the ecosystem; has identified and promoted participation in 6 European projects and consortia; has collaborated with agents of the ecosystem such as ESA-BIC, ACCIÓ, different departments of the Government of Catalonia and research entities such as IRTA, ICFO, CIMNE, etc.; has collaborated with the organisation and participated in conferences in Catalonia such as the NewSpace Economy Congress (see Image 11) and the annual conference of the NewSpace community of the DCA; has collaborated in the organisation of events such as the Space Generation (SGAC) in the Spanish edition; has collaborated in dissemination events (e.g. European Parliament, webinars in Nereus, Andalusian Government), etc. This year has also allowed us to establish the basis for interacting more efficiently with finalist sectors, such as the agricultural sector, and a business acceleration programme has been designed to encourage investment and will be launched during 2024.

Image 11: The NewSpace Economy Congress 2023 was held at Llotja de Mar (Barcelona) on 22 and 23 November. Upper: round table 'Constellations of small satellites', moderated by the director of the APEC, Josep Colomé. Lower: institutional representatives together with some outstanding invited speakers. Credits: IEEC / Barcelona Chamber of Commerce.

It is important to highlight the effort dedicated to the activities for the internationalisation of the NewSpace ecosystem. In this area, we have participated in 17 international fairs and congresses, and we have organised for the first time the assistance of the Catalan ecosystem at the Space Tech Expo Europe fair in Bremen, achieving great participation success (see Image 12). In addition, we have collaborated with the Government of Catalonia in the preparation of the Disruptive and Emerging Technology Alliance (DETA) project. Involvement in international organisations has also increased with the entry of Josep Colomé, director of the APEC, into the Management Board of the NEREUS association, in which the IEEC acts as a representative of Catalonia as a European region. At the same time, the APEC has continued to actively participate in the Earth Observation working group of the same NEREUS association and has continued to collaborate with the Eurisy association and the European Centre for Space Economy and Commerce (ECSECO) driven by the ESA.

In the area of ecosystem services, the NewSpace Lab has also continued to be promoted by completing the mapping of public and private infrastructures that generate impact in the NewSpace sector. The mapping, with more than 30 infrastructures from 10 companies and public entities, has been disseminated at events such as the International Astronautical Conference (IAC) held in Baku (Azerbaijan) and the NewSpace Economy Congress in Barcelona.

Finally, the APEC has developed actions to encourage the use of services based on space technologies, drawing on public procurement tools that allow the private sector to develop applications and pre-commercial solutions. The IEEC has signed two industrial contracts with companies that develop applications for private users in the agricultural sector, and has collaborated in the definition and evaluation of innovative public procurement contracts in collaboration with Ferrocarrils de la Generalitat de Catalunya (FGC) for the use of GNSS in the management of railway convoys.

Image 12: General image of the 'NewSpace Catalonia' stand, promoted by the Government of Catalonia with the support of the IEEC, during the Space Tech Expo Europe 2023, held in Bremen (Germany) from 14 to 16 November. Credit: IEEC

Talent

Within the framework of the activities for the creation and attraction of talent, the APEC develops actions to achieve the growth of the NewSpace sector in the medium and long term, and it does so collaborating with bodies of the Generalitat, of the academic field, civil society, etc. Actions are carried out based on specific programmes or reinforcing existing programmes at the different training stages, taking advantage of the inspiring potential for future generations of space technologies and research.

In 2023 the APEC has collaborated in different activities for secondary school students, such as the CanSat competition, promoted by the ESA and driven in Catalonia by the UPC and the Generalitat, which had the participation of dozens of secondary schools, or the scientific stays of the Fundació Catalunya La Pedrera. At the higher education levels, the APEC has also promoted the participation of the NewSpace ecosystem in business forums at different universities, organised the NASA Hackathon in Barcelona for the first time, and launched the programme for internships in companies aimed at university degrees with training linked to technologies in the NewSpace sector. Finally, grants have been awarded for the first time to attend the International Space University training courses 'Executive Space Course' (ESC) and 'Space Studies Program' (SSP), within the framework of a collaboration agreement to promote the entry into the NewSpace sector of new professionals.

Development and innovation in NewSpace

The APEC promotes R&D lines within the framework of the NewSpace Strategy of Catalonia that have a potential impact on the industrial sector and a short time to get to the market, with the aim of facilitating the transfer of key technologies to the productive sector. They are grouped into three main areas and cover Earth observation and GNSS technologies.

During 2023, the activities of 2022 in upstream and downstream for Earth observation and in LEO-PNT positioning systems have continued. Outstanding results have been obtained in all activities, whether from industrial agreements, collaborations with research centres, publications in journals, degree theses, or the development of new prototypes. One of the activities has made it possible to test the C3SatP high-performance computing platform on board the 'Menut' mission.

Infrastructures and data

In the field of infrastructure, the APEC promotes satellite data services through the launch of missions in LEO orbit. These services enable innovation in services based on Earth observation payloads and dedicated missions that complement large infrastructures of European programmes such as Copernicus. Satellite services are provided to the IEEC, which collaborates with other R&D centres, departments and bodies of the Government of Catalonia, for the study of different use cases and their possible applications. Specifically, these activities are carried out in collaboration with the i2Cat Foundation and the Cartographic and Geological Institute of Catalonia (ICGC). Ultimately, these services are aimed at creating an ecosystem that encourages the growth and consolidation of the NewSpace sector based on digital technologies. The APEC also collaborates in the construction of the Alguaire rocket engine test centre and the construction and management of the teleport for satellite communications at the Montsec Observatory.

The year 2023 began with the successful launch of the 'Menut' mission (see Image 13). The commissioning phase and the beginning of the operations phase have been carried out within the framework of the industrial contract with the company OpenCosmos Europe. The operations and exploitation of the mission has been managed in collaboration with the ICGC. And the tests of the C3SatP platform have been successfully carried out on board 'Menut'. During 2023, the contracting of services based on a new Earth observation mission, more ambitious than 'Menut' and that will allow a new satellite to be placed in orbit at the end of 2025, has also been launched.

As for the ground segment, during 2023 the contract for the construction of the Alguaire Rocket Engine Test Centre has begun (see Image 14). The contract, signed between Aeroports de Catalunya and the company Pangea Aerospace, is a step forward to have the necessary facilities to qualify engine technology for micro-launchers, as well as to test satellite propulsion engines. The APEC collaborates with Aeroports de Catalunya in this infrastructure within the framework of the collaboration agreement with the IEEC. The suitability of this infrastructure has also been reinforced with the award of the EU-Best European project, which envisages the deployment in Alguaire of similar infrastructures and as a technological demonstrator for future test equipment for micro-launchers. In relation to the teleport of the Montsec Observatory, during 2023 the contract has been awarded for the extension of network and electricity services of the observatory and which is necessary in order to provide these services to the new X/S band communications station expected to be built during 2024.

Image 13: Institutional representatives during the broadcast of the launch of the nanosatellite 'Menut', on 3 January, 2023. From left to right: Rafael Jordà Siquier, CEO of Open Cosmos; Gina Tost i Faus, secretary of Digital Policies; Roger Torrent i Ramió, Minister of Business and Labour of the Government of Catalonia; Ignasi Ribas Canudas, director of the IEEC; and Miriam Moysset, director of the ICGC. Credit: Generalitat de Catalunya

Image 14: Aerial view of the rocket engine test centre at Lleida-Alguaire airport, where the new modular test bench of the "European Bench for Engine and Stage Testing" (Eu-BEST) project, selected by the European Commission through its Horizon Europe funding programme, will be installed. Credits: Aeroports de Catalunya

Knowledge Transfer and Innovation

KNOWLEDGE TRANSFER AND INNOVATION

A Knowledge and Technology Transfer Strategy (KTTS) is fundamental to outline how the IEEC can transfer its expertise, knowledge, and technology to external partners in order to promote economic development, foster collaborations and partnerships, and to have a positive social and environmental impact. As a space research centre, this strategy should involve identifying and leveraging the expertise, capabilities, and intellectual property developed by the IEEC members to benefit other organisations, industries and communities.

One of the key aspects of the strategy envisages the commercialization of research. By licensing its technology or forming partnerships with industry, the IEEC can turn its research into marketable products and services that can benefit society. By partnering with industry, the IEEC can help to accelerate the adoption of new technologies and improve the productivity and competitiveness of businesses in the sector.

Defining a strong strategy will help to ensure that the knowledge generated within the IEEC is effectively disseminated to stakeholders and end-users who can benefit from it. Overall, identifying valuable IP assets, building strategic partnerships, and establishing effective collaboration and licensing agreements is of key importance. Furthermore, a well-defined knowledge and technology transfer strategy can help to create a culture of innovation within the centre. By promoting a focus on commercialization and technology transfer, researchers are incentivized to think on practical applications of their work. And for such activities, it is important to generate and to establish a resilient network of contacts composed of different actors, such as companies, governmental and non-governmental institutions, researchers, professionals in the space field and organisations.

On the one hand, the IEEC's Knowledge and Technology Transfer Office (KTO) acts as a connection point between these actors, facilitating communication and collaboration between them. Working to build a dynamic and diverse network that seeks to promote the transfer of knowledge and technology from the space field to society.

IEEC KTO also promotes the participation of researchers and other technical members in funding programmes and initiatives (Image 15). It coordinates and promotes projects and proposals and establishes partnerships with other entities, broadening the spectrum of sectors and fields of interest for the knowledge and technological developments of the different research groups.

Image 15

On the other hand, the IEEC's Project Management Office (PMO) provides structure and support to ensure that projects are delivered within the defined budget, schedule and scope. A PMO oversees and provides guidance in areas such as project planning and scheduling, budget control, project status tracking and reporting, risk and issue management, change management and human resource management.

The primary functions of the PMO are:

- Managing project resources and resolving resource-related issues
- Creation and update of project management processes and policies
- Identifying best practices, managing the project portfolio and collaborating with other teams and departments in the institutes.

Image 16

The PMO must be able to respond quickly and effectively to the problems that arise in its area, trying to make the right decisions and assessing the risks and scope of their actions.

Overall, KTO and PMO are essential to maximise the value of its research and development efforts. By defining a clear strategy and implementing it effectively, the IEEC will reinforce that the knowledge and technology from its members are making a real-world impact and contributing to the greater good.

As an important final remark, IEEC KTO and PMO also closely collaborate with the corresponding offices belonging to the different trustee institutions for knowledge transfer and project promotion at all levels (Image 16). And, in general, it is acknowledged the importance of the funding programmes enabling the multiple projects conducted at IEEC.

Success innovation cases

Hereafter there is the list of the new and ongoing innovation and transference projects with an IEEC member as Principal Investigator and where IEEC or one of its scientific units is in charge of its management. The activities are grouped by topic - following ESA topics as reference, as shown in Figure 1, that illustrates the ESA budget distributed by domain for next year, 2024 - to label relevant innovation activities carried out by the research groups, and the area of knowledge involved.

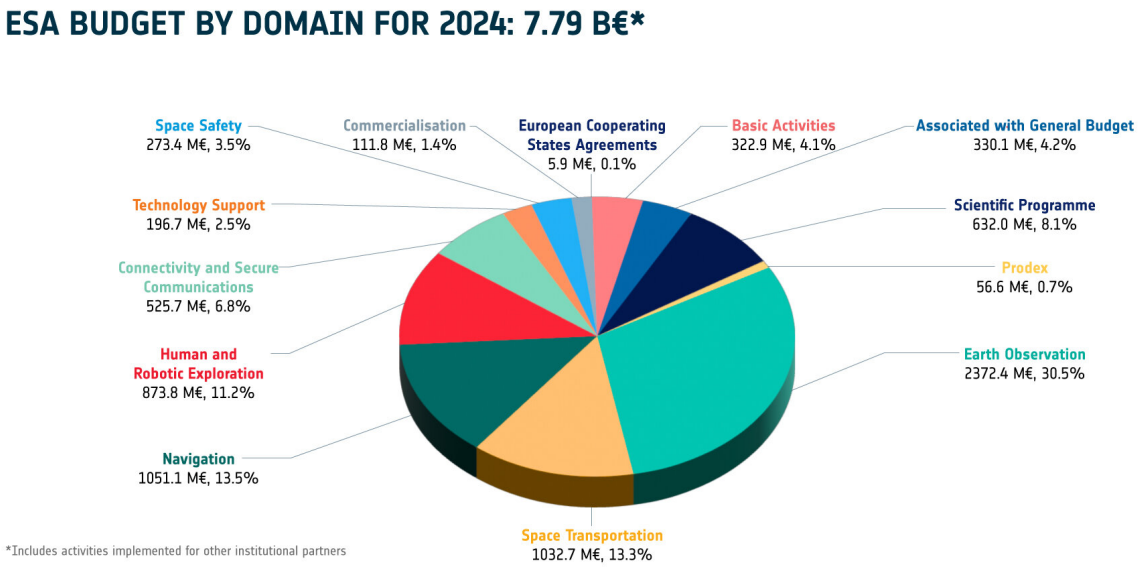


Figure 18

SCIENTIFIC PROGRAMME & GROUND-BASED INSTRUMENTS

Assessment on CTA Calibration and Environmental Monitoring (CTAO4)

CTAO gGmbH and IEEC have mutual interest in carrying out joint Research and Development Activities in the field of CTA Calibration and Environmental monitoring system with a view to preparing the implementation of the CTA. For this purpose, the collaboration agreement aims at defining the conditions in which IEEC undertakes to carry out the realisation of R&D activities in collaboration with CTAO, and in particular at defining the terms and conditions under which Dr. Markus Gaug, IEEC, shall provide support to CTAO in the realisation of such R&D Activities, given the expertise of Dr. Gaug on the CTA calibration and on the environmental monitoring of the future CTAO.

- *IEEC Contributors: Dr. Markus Gaug (PI), Juan Pedro, Lluís Font [IEEC-UAB]*
- *Funding Institution: Cherenkov Telescope Array Observatory gemeinnützige GmbH (CTAO)*
- *Duration: 01/2023 - 12/2023*

NAVIGATION

Assessment of Indoor positioning capabilities for LEO PNT (Emergency Indoor)

Indoor positioning technologies are primarily influenced by two significant use cases: 1) Industrial Internet of Things (IoT) requiring high precision, and 2) emergency call services. The latter demands accuracy within tens of metres across extensive areas, including rural and remote locations. Currently, emergency call locations rely on Global Navigation Satellite Systems (GNSS) outdoors and cellular networks indoors where GNSS is unavailable. In areas with limited access to base stations, such as indoors or remote locations, innovative satellite positioning using Low Earth Orbit (LEO) satellites could offer a promising solution. This is particularly feasible with the advent of stronger signal broadcast from LEO satellites across UHF, VHF, and S-band frequencies, coupled with advances in user-end technology like antenna miniaturisation. This segment of indoor users, typically involving static or slowly moving devices requiring moderate accuracy, is emerging as a key area of interest for LEO Position, Navigation, and Timing (PNT) systems. The responsibility of the IEEC team involves developing methodologies and algorithms to assess the signal losses from outdoors to indoors for real LEO signals, and enhancing the multipath resilience and accuracy of LEO signal ranging techniques.

- *IEEC Contributors: José A. López-Salcedo (PI), G.Seco-Granados, Fran Fabra [IEEC-UAB]*
- *Funding Institution: European Space Agency (ESA)*
- *Partners: Airbus (DE), Loctio (GR)*
- *Contract Nº: 4500719945*
- *Duration: 02/2023 - 03/2024*

SIS Attack Detection Functionality and LLA Additional Support (EGNOS V3 SIS-Attack)

Navigation Land Earth Stations (NLES) are a key element of EGNOS, the European Satellite-based Augmentation System (SBAS), which provides integrity information and improved accuracy to GNSS users within its geographically coverage area. EGNOS is currently undergoing a major upgrade with the development of its third generation, EGNOS V3, where IEEC already played a key role. In particular, through the development and validation of the long-loop algorithm (LLA) for steering the signal generated on ground by the NLES, and uplinked to EGNOS satellites. In the present SIS-Attack project, IEEC is developing a new functionality to be incorporated into future NLES stations, in order to detect potential spoofing or jamming attacks on the signal received from Space. The objective is to promptly report the presence of any potential threat, so that the system operator can implement the appropriate countermeasures.

- *IEEC Contributors: José A. López-Salcedo (PI), G.Seco-Granados [IEEC-UAB]*
- *Funding Institution: Indra (ES)*
- *Contract Nº: INDRA-EGNV3-LT-NLES-0620-IND*
- *Duration: 04/2023 - 03/2024*

SPACE SAFETY

EU-SST: Provision of optical sensor data for the space surveillance service

The EU Space Surveillance and Tracking is part of the Space Situational Awareness (SSA) component of the EU Space Programme, adopted by the European Union. CDTI represents the Spanish participation and coordinates the Spanish network of optical sensors for the provision of surveillance and tracking data of space debris.

- *IEEC Coordinator: Kike Herrero Casas (IP), Marc Ribó, Pere Gil, Francesc Domene, David Baroch, Gemma Domènech [IEEC-OdM], Josep Colomé [IEEC]*
- *Funding Institution: Centro para el Desarrollo Tecnológico Industrial (CDTI)*
- *Contract Nº: 5/2022 NEG (DPEERT/DERT) LOTE 2*
- *Duration: 01/2023 - 12/2023*

SWESNET - Space Weather Service Network extension

The Space Weather Service (SWE) Network in the ESA Space Safety programme consists of five expert service centres that provide crucial information on the space weather situation. The network provides services in the following domains: Solar Weather, Heliospheric Weather, Space Radiation, Ionospheric Weather and Geomagnetic Conditions. The IEEC-UPC group participates as part of the Ionospheric Weather expert service centre, contributing with real-time services for the GNSS-based solar flares' detection and monitorisation based on the world-wide distributed network of permanent GNSS receivers. Alerts are also triggered in case of solar flares impacting the Earth's ionosphere. In this new extension, a new reference ionospheric product is being provided through the SWE Network, which consists of 15-minute resolution Global Ionospheric Maps (GIMs), labelled UQRG. Furthermore, an extensive analysis of the feasibility to combine VTEC maps within the network has been conducted.

- *IEEC Contributors: Manuel Hernández-Pajares, Alberto Garcia-Rigo, Qi Liu [IEEC-UPC]*
- *Funding Institution: European Space Agency*
- *Partners: BIRA-IASB (Belgium; coordinator); 42 Europe-wide partners.*
- *Contract Nº: 68747/54.61/SWESNET-22-UPC-IonSAT*
- *Duration: 03/2023 - 02/2025*

SPACE TRANSPORTATION

EU-BEST: European Bench for Engine and Stage Testing

The Eu-BEST test bench is a European bench for rocket and stage testing which aims to be modular, interoperable and transportable to multiple hosting sites around Europe with capabilities up to 500 kN. The DEMO test for the bench will consist of a full test campaign of a LCH4/LOX aerospike engine in the hosting site located in the Airport of Lleida-Alguaire in the summer of 2026.

- *IEEC Contributors: Helena Carré Martell (PI), Lluís Montilla Rodríguez, Maria Casanovas Crespo [IEEC]*
- *Funding Institution: European Commission - Horizon Europe Programme*
- *Partners: Eiffage Energy Systems Clemessy, Space Dreams, OHB Digital Connect Gmbh, SUAS Aerospace Limited, Pangea Aerospace SL, Aeroports Públics de Catalunya SLU*
- *Contract Nº: 101135284*
- *Duration: 11/2023 - 10/2026*

COMMERCIALISATION & TRANSFERENCE

Contract for the transfer of a non-exclusive license by IEEC in relation to the C3SatP Software and Hardware

Provision by IEEC of a Non-Exclusive License in certain specific terms to install, modify and use the following IEEC Intellectual Property: C3SatP Software and Hardware, property of IEEC, comprising the C3SatP On-Board Computer (OBC), the C3SatP On-Board Data Handling (OBDH) and the C3SatP Software Defined Radio (SDR) subsystems.

- *IEEC Contributors: Juan José Ramos (IEEC-UPC), José María Gómez Cama (IEEC-UB), Xavier Casajoana (IEEC), Daniel Ferrer (IEEC), Pierre Gallarday (IEEC), Jan Gómez Escoda (IEEC), Jean-Jacques Metge (IEEC), Màrius Montón (IEEC-UAB), Carles Sierra (IEEC)*
- *Contract date: 10/2023*

Network for the transfer of high-performance supercomputing technologies to society (X4HPC network)

The main objective of the X4HPC supercomputing network is to manage and unite the ecosystem of research centers, companies and institutions that have as a common denominator the development of technological solutions based on supercomputing. The X4HPC also aims to transfer technology and knowledge in the area of high-performance computing (HPC) to facilitate progress in various economic and social fields, with special emphasis on Computer Sciences, Life Sciences, Earth Sciences and Engineering. The X4HPC has the will to lead the transfer of innovative applications of high-performance computing in new areas such as the development of new processors, the design of artificial intelligence solutions, solutions to combat climate change, solutions for genome sequencing and applications for the simulation of complex phenomena.

- *IEEC Coordinators: Xavier Luri, Carme Jordi [IPs; IEEC-UB]*
- *Funding Institution: AGAUR Reference: 2021 XARDI 00016*
- *Partners: BSC; 23 research groups (10 from UB, including "Grup Gaia Universitat de Barcelona")*
- *Duration: 01/2023 - 12/2025*

TALENT & EDUCATION

6th CASSINI Hackathon: Space for International Development and Humanitarian Aid

Europe-wide CASSINI Hackathons are a major opportunity to develop ideas for a digital application building on space data, including satellite images and positioning services. They are particularly addressed to students, graduates, researchers and teams/start-ups in their very early stages. Each hackathon takes place simultaneously in ten European cities and the local organisers will offer everything you need to form a great team, learn about accessing space data, identifying customer needs, and start working on your digital solution.

- *IEEC Contributors: Maria Casanovas Crespo (PI), Alberto Garcia-Rigo [IEEC-KTO]*
- *Funding Institution: European Union Agency for the Space Programme (EUSPA)*
- *Partners: Fundació KIM Barcelona (KIM Bcn), Cambra de Comerç de Barcelona (CCB), Institut Cartogràfic i Geològic de Catalunya (ICGC)*
- *Duration: 05/2023 - 11/2023*

Scientific Highlights

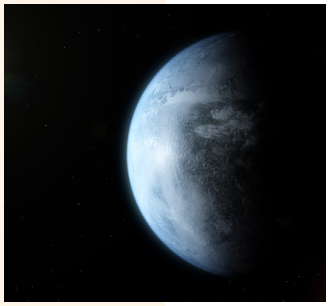
SCIENTIFIC HIGHLIGHTS

Supermassive black holes found in distant dwarf galaxies

An international team that counts with the participation of the IEEC and the Spanish National Research Council (CSIC) discovered supermassive black holes in dwarf galaxies when the Universe was much younger than it is today, 6 billion years after the Big Bang. This is a very unusual finding since very few cases had been discovered in the local universe—the universe today (13.6 billion years after the Big Bang). The study was published in The Astrophysical Journal Letters.

CARMENES project boosts the number of known planets in the solar neighbourhood

In February, the CARMENES project published data from about 20,000 observations taken between 2016 and 2020 for a sample of 362 nearby cool stars. The project used an instrument at Calar Alto Observatory with the purpose of finding Earth-like exoplanets. Notable among the multitude of released data measurements are those that have led to the discovery of 59 exoplanets, a dozen of which are potentially habitable. The study, published in Astronomy & Astrophysics, involved more than 100 scientists and engineers, with a prominent role of IEEC researchers at the Institute of Space Sciences (ICE-CSIC).



The collision of the DART probe with the asteroid Dimorphos resulted in the ejection of more than five million kilos of material

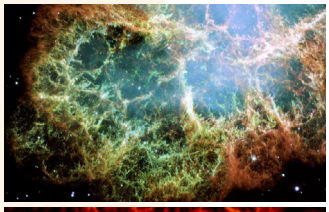
On 27 September 2022, NASA's DART (Double Asteroid Redirection Test) mission collided with its target, the asteroid Dimorphos, and changed its orbit. It was the first planetary defence test mission designed to change the course of an asteroid and its success was followed by intensive analysis of the collision, including study of the tonnes of rock that were displaced and hurled into space. The results of these analyses are published in four papers in the journal Nature, which involved a team from the IEEC at the Institute of Space Sciences (ICE-CSIC).

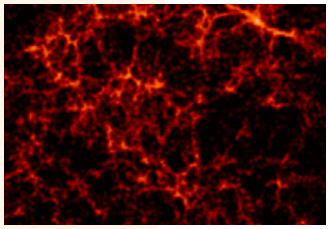
How does the immune system react to altered gravity?

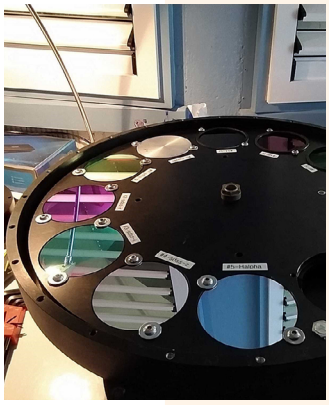
A study by the University of Barcelona, the Universitat Politècnica de Catalunya - BarcelonaTech (UPC) and the Germans Trias i Pujol Research Institute analysed the effects of a short exposure to altered gravity on the defensive cells of the human body. The research had the outstanding participation of IEEC researcher Antoni Pérez-Poch. Microgravity conditions were generated during a short parabolic flight—with fifteen parabolas—in an aerobatic aircraft. The paper is published in the journal Acta Astronautica.

A model of the universe explains its accelerated expansion without the need for dark energy

The accelerated expansion of the universe would not need dark energy, according to a study published in the journal Monthly Notices of the Royal Astronomical Society: Letters. The author of the paper is Enrique Gaztañaga, IEEC researcher at the Institute of Space Sciences (ICE-CSIC). His research, of a theoretical nature, shows that the cosmic expansion can be derived simply from the fact that our universe has a very large, but finite, mass. This would lead to boundary effects equivalent to those of dark energy or a cosmological constant.

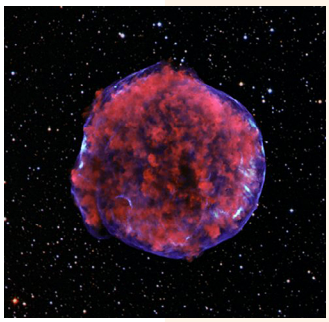






New filters for the Joan Oró Telescope of the Montsec Observatory

The Montsec Observatory, a state-of-the-art scientific infrastructure managed by the IEEC, installed a new set of filters in the Joan Oró Telescope (TJO) to improve its performance. The telescope incorporates four SDSS system filters and an H-alpha filter that will allow more accurate observations. These filters are used in a wide variety of astronomical topics, including the study of star formation and evolution, supernovae, and binary systems, among others. The telescope also has a new automatic planning system for real-time observations.

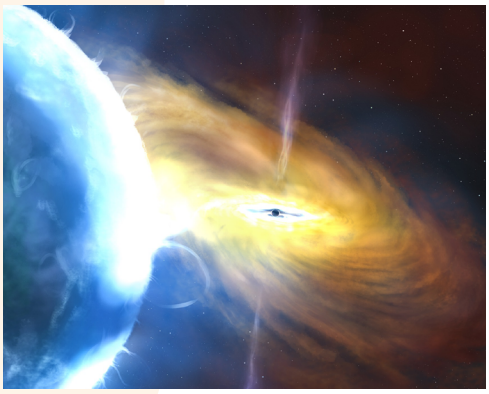


Understanding the origin of the most energetic stellar explosions in the universe

A team of scientists studied the superluminous supernova SN2017egm to investigate the energy source and mechanisms behind these phenomena. The IEEC, through the Institute of Cosmos Sciences of the University of Barcelona (ICCUB), participated in this research led by prof. Xiaofeng Wang from Tsinghua University and published in Nature Astronomy. The study suggests that during its final instability period the star emitted four shells of circumstellar material, which later interacted with the material ejected in the explosion creating a very intense and complex luminosity pattern.

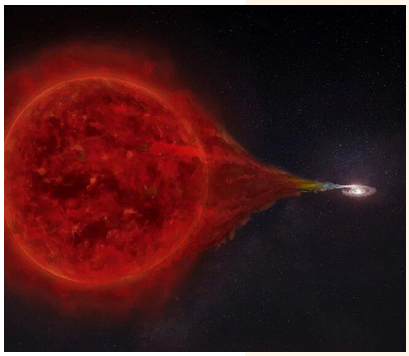
Astronomers reveal the largest cosmic explosion ever seen

An international team of astronomers, led by the University of Southampton and with the participation of IEEC researchers at the Institute of Space Sciences (ICE-CSIC), uncovered the largest cosmic explosion ever witnessed in an article published in Monthly Notices of the Royal Astronomical Society. The explosion is more than ten times brighter than any known supernova and took place nearly 8 billion light years away, when the universe was around 6 billion years old.



BlackGEM telescopes begin hunt for gravitational-wave sources at ESO's La Silla Observatory

The BlackGEM array, consisting of three new telescopes located at ESO's La Silla Observatory, began operations. The BlackGEM survey will scan the southern sky to hunt down the cosmic events that produce gravitational waves, such as the mergers of neutron stars and black holes. The IEEC participates in the survey through Nadejda Blagorodnova, researcher at the Institute of Cosmos Sciences of the University of Barcelona (ICCUB).

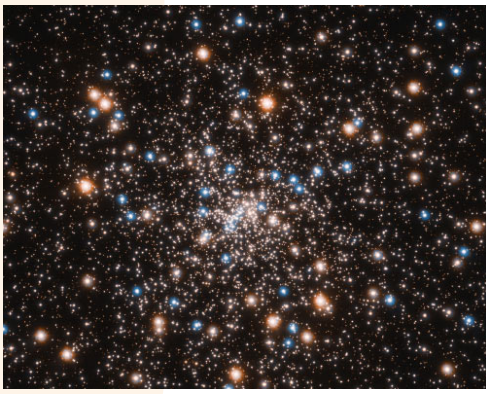


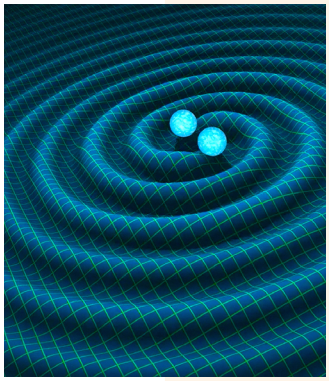
Gamma-ray emission from a recurrent nova confirms a 2006 prediction

The explosion of a recurring nova in 2021 detected in gamma rays confirmed the predictions made in 2006 by Margarita Hernanz, IEEC researcher at the Institute of Space Sciences (ICE-CSIC), in collaboration with Vincent Tatischeff (IJCLab, Université Paris-Saclay). RS Ophiuchi is an unstable binary system formed by a red giant star and a white dwarf, which regularly experiences thermonuclear explosions on top of the white dwarf, called nova explosions.

Supermassive stars at the origin of globular clusters

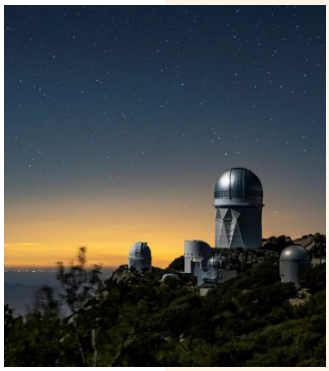
The chemical composition of stars born in the most massive and oldest star clusters in the universe shows anomalies that are not found in any other population of stars. A team of researchers with IEEC participation through the Institute of Cosmos Sciences of the University of Barcelona (ICCUB) found traces of supermassive stars that can explain the anomalies observed in large clusters of stars. The results, obtained thanks to observations by the James Webb space telescope, are published in the journal Astronomy and Astrophysics.





Gravitational wave detectors start next observing run to explore the secrets of the universe

The LIGO-Virgo-KAGRA (LVK) Collaboration began a new observing run with upgraded instruments, new and more accurate signal models, and more advanced data analysis methods. The LVK collaboration consists of scientists across the globe who use a network of observatories—LIGO in the United States, Virgo in Europe, and KAGRA in Japan—to search for gravitational waves, or ripples in space-time, generated by colliding black holes and other extreme cosmic events. The IEEC participates in Virgo through the Institute of Cosmos Sciences of the University of Barcelona (ICCUB).

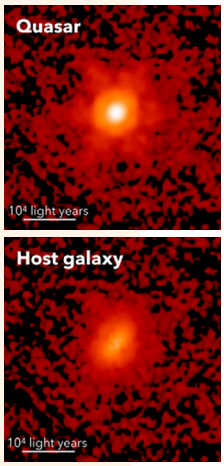


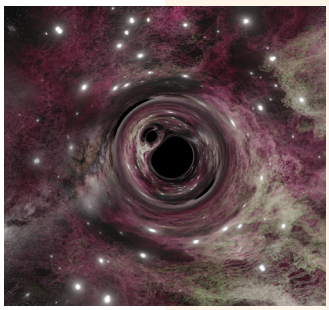
DESI early data release holds nearly two million objects

The first batch of data from the Dark Energy Spectroscopic Instrument (DESI) was made available for researchers to mine. Taken during the experiment's "survey validation" phase, the data include distant galaxies and quasars as well as stars in our own Milky Way. DESI has already observed more galaxies than the combination of any other previous study, and it has just started. Several Spanish institutions participate in this project, including two IEEC research units: the Institute of Cosmos Sciences of the University of Barcelona (ICCUB) and the Institute of Space Sciences (ICE-CSIC).

Researchers detect the host galaxies of quasars in the early universe

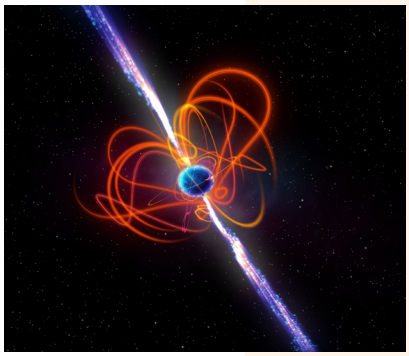
The James Webb Space Telescope revealed starlight from two massive galaxies hosting actively growing black holes—quasars—seen less than a billion years after the Big Bang. A new study in the journal Nature found the black holes have masses close to a billion times that of the Sun, and the host galaxy masses are almost one hundred times larger, a ratio similar to what is found in the more recent universe. How could these black holes grow to be so large when the universe was so young? Kazushi Iwasawa, IEEC researcher at the Institute of Cosmos Sciences of the University of Barcelona (ICCUB) is one of the core members of the team that discovered the early-universe quasars.





Unveiling the origins of merging black holes in galaxies like our own

POSYDON is the newly released open-source software used to generate detailed single and binary star simulations to predict the evolution of isolated binary systems. It was used for the first time to investigate merging binary black holes, providing new insights into the formation mechanisms of merging black holes in galaxies like the Milky Way. Konstantinos Kovlakas, IEEC researcher at the Institute of Space Sciences (ICE-CSIC), has participated in the study, published in the journal Nature Astronomy.

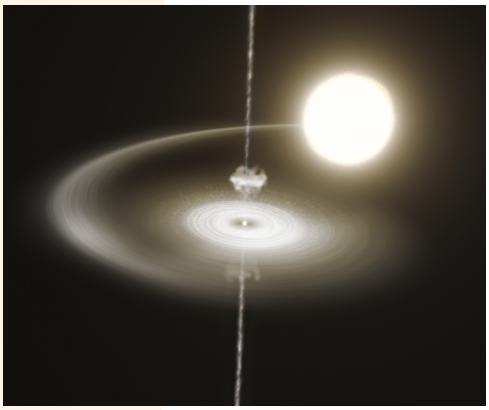


Astronomers discover a new type of stellar object hiding in plain sight

An international team with the participation of IEEC researchers at the Institute of Space Sciences (ICE-CSIC) discovered a new type of stellar object. Hidden in plain sight—its existence had been recorded in 1988—this new object raises new scenarios in the physics of neutron stars and white dwarfs: the radio waves emitted by the object are the longest ever detected, possibly originating from a magnetar or a white dwarf. The finding was published in the journal Nature.

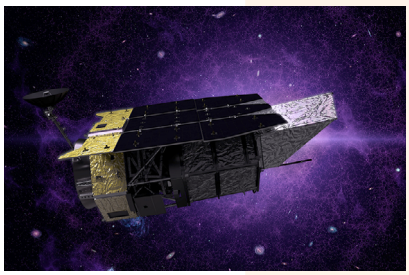
Astronomers unravel a pulsar's bizarre behaviour

An international team of astronomers uncovered the strange behaviour of a pulsar—a super-fast-spinning dead star—that switches between two brightness modes almost constantly. Thanks to an observational campaign that involved 12 telescopes both on the ground and in space, including three European Southern Observatory's facilities, the team found that sudden ejections of matter from the pulsar over very short periods are responsible for the peculiar switches. The research, published in Astronomy & Astrophysics, had the contribution of IEEC researchers at the Institute of Space Sciences (ICE-CSIC).



The closest black holes to Earth could be in the Hyades star cluster

A group of scientists published new results that hint at the existence of two or three black holes in the Hyades cluster—located about 150 light-years away—, making them the closest black holes to Earth ever detected (ten times closer than the nearest known black hole). Simulations were compared with real data obtained with the Gaia mission of the European Space Agency (ESA). The study had the collaboration of IEEC researchers at the Institute of Cosmos Sciences (ICCUB).



The Roman Space Telescope will be launched in 2027 to discover the true nature of dark energy

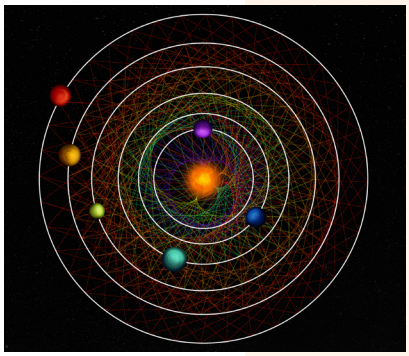
NASA's Nancy Grace Roman Space Telescope is an observatory designed to settle essential questions in the areas of dark energy, exoplanets, and infrared astrophysics, and is planned to be launched in 2027. Lluís Galbany, IEEC researcher at the Institute of Space Sciences (ICE-CSIC), participates in a research group that has been awarded $11 million to develop the tools needed to utilise as cosmological probes the thousands of supernovae that Roman will discover.

ESA's PRETTY mission is in orbit

Last 9 October 2023, the European Space Agency (ESA) PRETTY mission was launched into space. PRETTY will develop altimetry techniques for a precise measurement of the topography of the sea and ice from space. IEEC researchers at the Institute of Space Sciences (ICE-CSIC) will work with the first results of the mission. The study of the marine surface will foster scientific research in areas such as climate, fisheries management or cyclone prediction.

A stellar corpse shows signs of life through unprecedented flares

An active stellar corpse, caused by a distant star's explosive death, was the likely source of repeated energetic flares observed over several months. The explosions were far brighter than the violent ends massive stars typically experience, but faded in days instead of weeks.
IEEC researchers at the Institute of Space Sciences (ICE-CSIC) participated in this study published in the journal Nature.

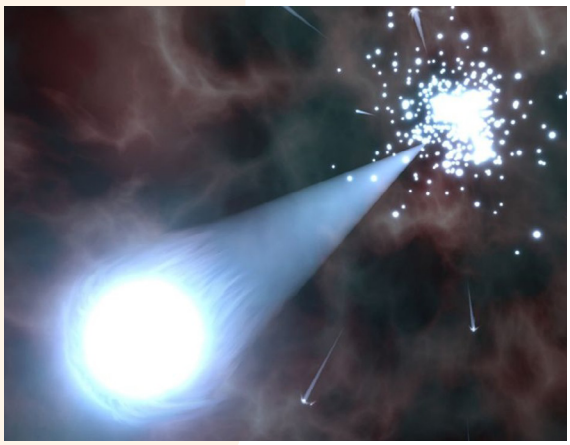


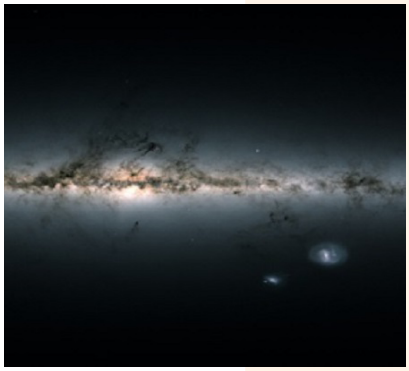
Astronomers discover six planets thanks to their synchronised orbits

The planets orbit their central star in sync, following a predictable rhythm astronomers call 'resonance'. This configuration shows that the planetary system has not suffered major changes since its formation more than a billion years ago. IEEC researchers at the Institute of Space Sciences (ICE-CSIC) participated in this discovery, published in the journal Nature, which uses observations from the CARMENES instrument in Calar Alto and data from the ESA CHEOPS mission.

Breakthrough study identifies many massive runaway stars in the Milky Way

A significant population of stars in the Milky Way is running away from their neighbours. A ground-breaking study carried out by IEEC researchers at the Institute of Cosmos Sciences of the University of Barcelona (ICCUB) identified a considerable number of these 'runaway stars', as astronomers call them, in our galaxy. The results are published in Astronomy & Astrophysics.





The European SPACIOUS project, funded with 1.9 million to manage massive data in space science

SPACIOUS will establish a new technological scenario to facilitate more efficient exploitation of massive datasets with analysis methodologies that exceed current expectations. The project will be instrumental in the Gaia and Euclid space missions, both of the European Space Agency and with prominent participation of IEEC researchers. SPACIOUS is led by Xavier Luri, director of the Institute of Cosmos Sciences (ICCUB) and member of the IEEC.

Institutional News and Highlighted Events

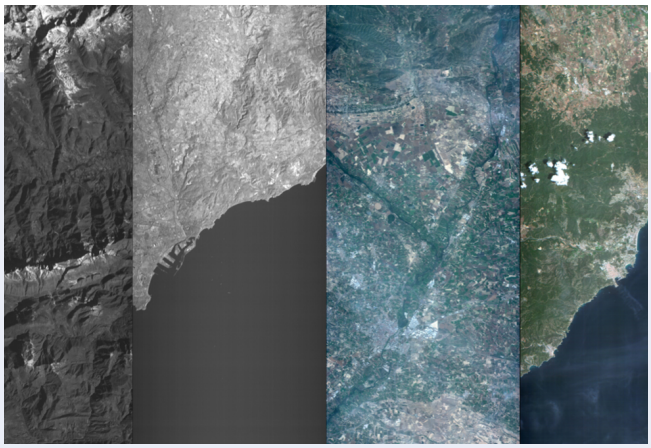
INSTITUTIONAL NEWS AND HIGHLIGHTED EVENTS

‘Menut’ operates from space to help improve land management and fight the effects of the climate crisis

‘Menut’ (small, in Catalan) is the second satellite mission—and the first devoted to Earth Observation—of the NewSpace Strategy of Catalonia promoted by the Catalan Government. On 3 January, ‘Menut’ was successfully launched from the Cape Canaveral Spacebase in Florida (USA). The launch took place at 15:56h (CET) aboard a Falcon 9 rocket launcher from SpaceX. 62 minutes later, the rocket launcher ejected the Catalan nanosatellite into its target orbit, at 538 km from Earth. The director of the IEEC, Ignasi Ribas, followed the take-off live from the headquarters of Open Cosmos in Barcelona, together with representatives of the Government of Catalonia and the Cartographic and Geological Institute of Catalonia, among others.

Just over a month after take-off, ‘Menut’ provided its first Earth images obtained from space

‘Menut’ successfully closed the commissioning stages, aimed at validating the functionality of the different elements and systems of the nanosatellite, and we already regularly receive processed images of Catalonia. Technical teams from the IEEC, the Cartographic and Geological Institute of Catalonia and Open Cosmos continue to work together to refine the quality of its data and be able to apply it to several use cases.



The first images of ‘Menut’ over Catalonia, acquired on 18 February, show Pedraforca (Cerdanya area) and Tarragona in infrared. Lleida, Palafrugell, and other places were captured in other acquisitions. Monitoring the same areas will serve to assess the evolution of the territory with regards to, for instance, the impact of drought on crops —and contribute to improving water management— or the delimitation of the effects caused by extreme weather events such as floods and river sediments plumes in coastal waters.

Aerospace PERTE to promote the sector's industry

On 19 January, the event presentation of the Aerospace PERTE, the Strategic Project for the Recovery and Economic Transformation (Proyecto Estratégico para la Recuperación y la Transformación Económica) was held in Barcelona. This project is intended to promote the Spanish aerospace industry, with the aim of making it a key player in the sector. The event was organised by the Government of Catalonia and the IEEC, in collaboration with the DCA-NewSpace. Ignasi Ribas, director of the IEEC, presented the space sector in Catalonia.

The IEEC receives funding from the 'Complementary plan' for Astrophysics and High-Energy Physics to develop the PhotSat satellite

The presentation of the Astrophysics and High-Energy Physics 'Complementary plan' (Planes Complementarios) of the Spanish Government took place on 9 February in the auditorium of the Faculty of Science of the Universitat Autònoma de Barcelona (UAB). This programme has a budget of 39 million euros between 2023 and 2026. The IEEC will receive 3.6 million euros to finance the PhotSat project. This involves the development and construction of a satellite to track the 10 million brightest stars in the sky for at least two years.

Successful participation in the event Catalonia AI4EO

The Catalonia AI4EO Day ('Artificial Intelligence for Earth Observation') took place on 21 February, and focused on Artificial Intelligence (AI) applied to Earth Observation (EO) and Remote Sensing in Catalonia. The event was organised by the IEEC and the Government of Catalonia as part of the NewSpace Strategy of Catalonia, with the collaboration of the Artificial Intelligence Research Alliance (AIRA) and the Digital Catalonia Alliance (DCA). More than 70 attendees, 25 companies, 15 research centres and 2 public entities participated in the event, held at the CSIC Researchers Residence in Barcelona.

The Catalan aerospace ecosystem, presented in Brussels to the leading actors of the sector

The event “Regions as Key Players in European Space Policy” was held on 20 March, at the Espai Catalunya Europa of the Delegation of the Government of Catalonia to the European Union, in Brussels. The conference was jointly organised by this Delegation, NEREUS (Network of European Regions Using Space Technologies) and the IEEC. The event aimed to highlight the potential of the aerospace Catalan sector, while giving visibility to the contribution of this sector at the European level.

‘NewSpace Catalonia’ scholarships for the ISU Executive Space Course

In the framework of the objectives of the Talent and Society programme of the NewSpace Strategy of Catalonia, last 1 March the Generalitat de Catalunya and the IEEC launched a call for 3 scholarships to participate in the intensive Executive Space Course - ESC. This programme is aimed at promoting activities to attract, generate and retain all the talent with the capacity to develop solutions in the NewSpace field in Catalonia.

Josep Colomé, appointed member of the Management Board of NEREUS

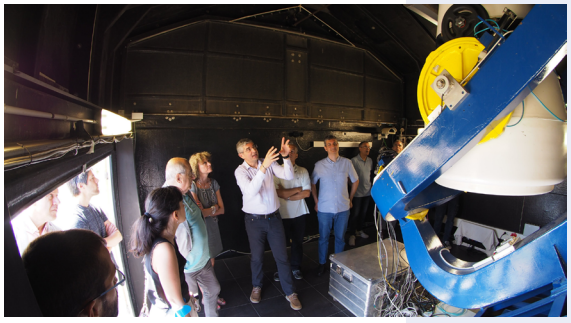
The director of the Area for the Promotion of the Space Sector of Catalonia (APEC) at the IEEC, Josep Colomé, has been appointed member of the Management Board of NEREUS (Network of European Regions Using Space Technologies), a network to explore the benefits of space technologies for citizens, as well as to promote the use of space and its applications.

1st Annual DCA-NewSpace Community Conference

The NewSpace community of the Digital Catalonia Alliance (DCA-NewSpace) invited its members and collaborating organisations to its first annual conference, which was held on 8 June, from 11:00 a.m. to 2:00 p.m., at the Centre de Cultura Contemporània de Barcelona (CCCB). The event was organised by the DCA and had the collaboration of the IEEC and ACCIÓ - Agència per la Competitivitat de l'Empresa.

The 5th IEEC Forum gathers more than 120 attendees at Cosmocaixa

On 21 June, the 5th IEEC Forum brought together more than 120 members of the IEEC community, as well as highlighted speakers from other institutions, at the Cosmocaixa Science Museum (Barcelona). The Forum had all kinds of presentations on astrophysics, cosmology, Earth observation and space technology, such as an excellent panel on gravitational waves. Speakers had a variety of formats to participate: from longer talks to short elevator pitches.



Minister Nadal visits the Montsec Observatory

Last 27 July, the Board of Trustees of the IEEC visited the Montsec Observatory. Joaquim Nadal, Minister of Research and Universities of the Government of Catalonia, was there as president of the board, together with Georgina Tost, Secretary of Digital Policies of the Department of Business and Work.

The IEEC participates in the International Space University's SSP 2023 summer programme

The Space Studies Program (SSP) is an intensive 9-week course organised by the International Space University (ISU), whose 35th edition took place in São José dos Campos (Brazil) during the summer months. It offers training in a wide range of space disciplines, through theoretical courses, workshops and professional visits. Ana Montaner, Head of the IEEC Communication Office, gave several workshops related to crisis communication and media training.

New websites released: IEEC and Montsec Observatory

The new IEEC website is already online! We encourage you to visit it and enjoy, among other things, the new sections. Among the most extended ones you will find the Innovation section, with a portfolio of technologies; the Training section, where we will be updating the awards and incentives; and all the information about our organisation and its administrative structure, which you can find in the Transparency section. As always, we will continue publishing the most relevant scientific news with participation of IEEC researchers, announcements of activities and initiatives in the space sector, and much more!

Moreover, the IEEC also published a new website dedicated exclusively, and for the first time, to the Montsec Observatory. We invite you to browse through its sections to learn more about it! Check the spectacular astronomical images of the image gallery and the live cameras of the facilities. Please notice that you can also find a specific section intended for professionals who want to send and manage scientific proposals to observe with the Joan Oró Telescope (TJO) and the Fabra – ROA Montsec Telescope (TFRM).

The IEEC publishes the tender for the new Earth Observation mission of the Catalonia's NewSpace Strategy

The IEEC announced the tender for the provision of satellite data services related to Earth Observation for next Catalonia's NewSpace Strategy mission. This mission will include the integration and operation of an in-orbit technology demonstrator (IOD). The provision of the services will include the conception, integration, and management of the entire life cycle of the satellite mission.

The rocket engine test centre at the Lleida-Alguaire airport gets off the ground

The Minister of Business and Work, Roger Torrent i Ramió, and the Minister of Territory, Ester Capella i Farré, chaired the act of presentation of the first step for the establishment of the rocket engine test centre at Lleida-Alguaire Airport, an infrastructure framed in the NewSpace Strategy of Catalonia promoted by the Government to foster the new space economy.

The IEEC participates in the second edition of the European Regional Symposium by NEREUS

The IEEC and the Cartographic and Geological Institute of Catalonia (ICGC) participated in the second edition of the European Regional Symposium by NEREUS (Network of European Regions Using Space Technologies), which took place on 28-29 September in Matera (Italy). Organised jointly by the NEREUS and the hosting region of Basilicata, this edition focused on the use of space data for tourism and agriculture.

Open call for the First Earth Observation Use Case Ideas Competition for the Private Sector

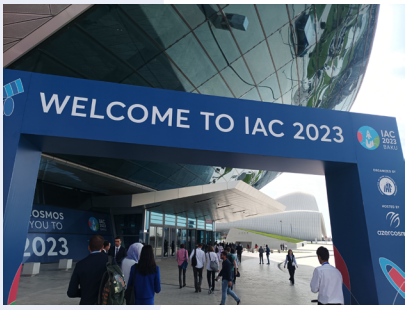
The IEEC and the Government of Catalonia opened a call to participate in the first Earth Observation Use Case Ideas Competition for the Private Sector. The initiative, framed within the NewSpace Strategy of Catalonia, seeks to obtain innovative proposals for Earth Observation use cases that the NewSpace ecosystem can offer to the Catalan private business sector as satellite information-based solutions. The companies selected were isardSAT (project: MARE -drought monitoring with high spatial resolution-) and SPASCAT (project: Espiadimonis).

Celebration of the Barcelona NASA International Space Apps Challenge 2023

NASA International Space Apps Challenge, one of the world's leading hackathons, returned to Barcelona on 6, 7 and 8 October 2023. Within the Talent and Society programme of the NewSpace Strategy of Catalonia, the IEEC collaborated as a sponsor and provided mentors and participants to join a team and compete to develop the best solutions for the challenges raised for this year's edition.

The IEEC participates for the third time in a row in the International Astronautical Congress

The IEEC participated for the third time in a row in the most important event within the space sector globally: the International Astronautical Congress 2023 (IAC), organised by the International Astronautical Federation and held in the city of Baku (Azerbaijan) between 2 and 6 October.



Catalonia presents a success story on the use of satellite data at the European Parliament

The 'Copernicus4regions' debate on the European Union's Earth Observation programme Copernicus was held at the European Parliament (Brussels). Organised by NEREUS (the network of European regions promoting the use of space technologies), the European Commission and the European Space Agency (ESA), the aim of the session was to highlight the value of the Copernicus programme for green policies related to climate change adaptation.

STARS workshop: space mission and ground-based observatory planning and scheduling projects

The IEEC organised, together with the Institute of Space Sciences (ICE-CSIC) and the Institute of Cosmos Sciences of the University of Barcelona (ICCUB), a workshop focused on the STARS (Scheduling Telescopes as Autonomous Robotic Systems) software package. Based on Artificial Intelligence (AI) algorithms and already successfully applied in several ground and space observatories, the STARS software aims to optimise coordinated multi-observatory scheduling while reducing operational costs.

The 6th Cassini hackathon promotes 6 projects to enhance international development and humanitarian aid through space technology

The 6th Cassini hackathon was held simultaneously from 3 to 5 November in ten European countries. The Catalan edition of the hackathon was organised by the Knowledge Innovation Market Private Foundation, the IEEC, the Cartographic and Geological Institute of Catalonia (ICGC) and the Barcelona Chamber of Commerce. It was held at the School of Telecommunications and Aerospace Engineering (EETAC) of the Universitat Politècnica de Catalunya – BarcelonaTech (UPC).

The NewSpace Strategy of Catalonia, represented at Europe's leading fair on space technology and services

On 14-16 November, the Government of Catalonia, with the support of the IEEC, presented the 'NewSpace Catalonia' stand at the Space Tech Expo Europe 2023, Europe's most relevant fair on space technology and services. The event is held annually in Bremen (Germany) and in its 6th edition gathered more than 650 exhibitors from more than 40 countries. Five companies from the Catalan space ecosystem—ASE Optics Europe, ICFO, isardSAT, Kreios Space and Osmium—had a dedicated space in the stand, where they could promote their services among the attendees of the congress.

The New Space Economy Congress 2023 establishes Catalonia as one of Europe's space knowledge hubs

The New Space Economy Congress 2023, organised by the Barcelona Chamber of Commerce and the Government of Catalonia, with the partnership of the IEEC, among others, was held at la Llotja de Mar (Barcelona). Its huge attendance success confirms the great potential of the NewSpace ecosystem in Catalonia. The congress featured top-level speakers who offered a detailed overview of the latest trends and opportunities in the sector.

Funding of student internships in companies and research centres in NewSpace projects

The IEEC and the Government of Catalonia opened a call for 8 grants to companies (SMEs), start-ups and research centres in Catalonia for the recruitment of a student intern in the NewSpace field. This call was framed within the actions of the Talent and Society programme of the NewSpace Strategy of Catalonia, with the purpose of promoting the space ecosystem of the territory and letting small companies, start-ups and research centres finance internships for university students in this field.

A European consortium with participation of the IEEC, Pangea and Aeroports de Catalunya obtains 4.9 million from the EU for the Eu-BEST project

The project will develop a European rocket engine test bench—open to the industry, flexible and modular—with capability for cryogenic and sustainable propellants, to be placed at the Lleida-Alguaire airport in Catalonia. Eu-BEST has been conceived and developed by a consortium of leading European companies and institutions—which also includes French, German, and Irish ones—under the leadership of the Eiffage Energie Systèmes - Clemessy company.

'Net of Networks', the meeting point for the Catalan NewSpace professionals inside and outside Catalonia

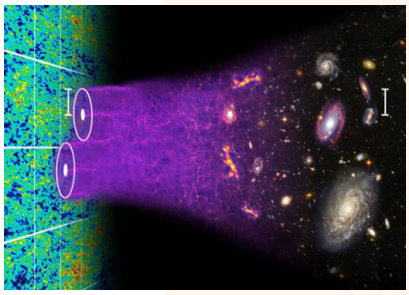
The NewSpace community of the Digital Catalonia Alliance (DCA) organised, with the collaboration of Women in Aerospace Europe (WIA-E), the 'Net of Networks' event. The meeting, held on 22 December at the i2CAT Foundation headquarters (Barcelona), was aimed both at members of the DCA-NewSpace community and at all Catalan professionals in the industry working abroad. The event focused on the importance of being part of a local, global and sectorial network and provided a space for conversation between speakers and attendees to exchange impressions and experiences.

Awards

AWARDS

Best Final Master's Thesis (2021/22) and Doctoral Thesis (2020/21 - 2021/22) Awards

The IEEC published the resolution of the Awards for Best Final Master's Thesis (TFM) defended during the academic year 2021/22 and Best Doctoral Thesis (PhD) defended during the academic years 2020/21 or 2021/22. The evaluated works could be defended in any of the institutions that make up the IEEC and were on topics specific to the Institute's research lines. Best Final Master's Thesis was awarded to the work 'The multiplicity fraction in 324 open clusters from Gaia', by Ms Judit Donada Oliu (Directors: Mr Friedrich Anders and Ms Carme Jordi Nebot). Best Doctoral Thesis, was awarded ex aequo to the works 'Analysis of high-precision spectroscopic and photometric data for planet and stellar characterization', by Mr David Baroch López (Director: Mr Juan Carlos Morales Peralta) and 'Development of novel instruments and techniques for passive microwave remote sensing', by Mr Joan Francesc Muñoz Martin (Director: Mr Adriano Camps Carmona).

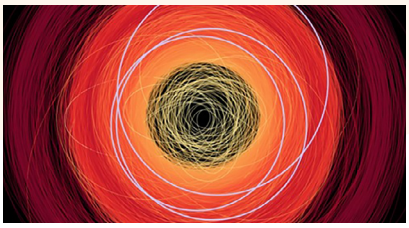


The 2023 Giuseppe and Vanna Cocconi Prize in cosmology awarded to the SDSS/BOSS/eBOSS collaborations

The SDSS/BOSS/eBOSS collaborations were awarded the 2023 Giuseppe and Vanna Cocconi Prize in cosmology by the High Energy and Particle Physics Division of the European Physical Society. These collaborations created the most detailed three-dimensional map of our universe and used the statistical properties of these maps to infer the geometry and structure growth of the universe from a billion years after the Big Bang until today. A number of IEEC researchers at the Institute of Cosmos Sciences of the University of Barcelona (ICCUB) have participated in these collaborations.

The International Astronomical Union names asteroid 2001 QH220 after researcher Jordi Portell

The International Astronomical Union (IAU) named the asteroid 2001 QH220 after Jordi Portell, IEEC researcher at the Technological Unit of the Institute of Cosmos Sciences of the University of Barcelona (ICCUB). This is a recognition of his outstanding work on asteroid data processing in the Gaia mission of the European Space Agency (ESA), where he coordinates several aspects of Gaia daily operations, including asteroid detection.



Héctor Gil-Marín is awarded the 2023 Leonardo Grant in Physics

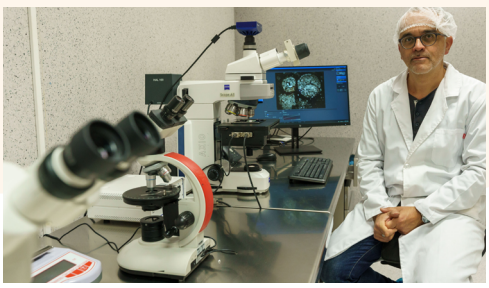
Héctor Gil-Marín, IEEC researcher at the Institute of Cosmos Sciences of the University of Barcelona (ICCUB) won one of the seven 2023 Leonardo Grants in Physics awarded by the BBVA Foundation. The evaluation committee decided to offer one of the grants to the ICCUB-IEEC physicist, to support his research on dark energy using the data of DESI (Dark Energy Survey Instrument) with cutting-edge analysis techniques to maximise the return of information and characterise some of the properties of dark energy.

IEEC Award for the Best Final Master's Thesis (2022/23)

The IEEC announced the resolution of the call 'Award for the Best Final Master's Thesis (TFM) 2022/2023' for works defended from 1 October 2022 to 30 September 2023 at any of the academic institutions that form the IEEC whose themes are aligned with its lines of research: Astrophysics, Cosmology, Earth Observation, Navigation, and Space Technology. This year, the winning work is: 'Development of a miniaturized low-noise magnetometer for space missions,' by Mr Xavier Manyosa i Vilardell, and directed by Mr Manuel M. Domínguez Pumar.

Josep M. Trigo is awarded the Joan Lluís Vives prize for his book 'Asteroid Impact Risk'

Josep M. Trigo-Rodríguez, researcher of the Institute of Space Sciences (ICE-CSIC) and member of the IEEC, won the Joan Lluís Vives University Publishing Award in the category of best science and technology book for 'Asteroid Impact Risk: impact hazard from asteroids and comets'.



Talent and Outreach Activities

Outreach and educational activities at the Montsec Observatory

This year, in commemoration of the centenary of Joan Oró's birth, different events have been organised at the Montsec Observatory (OdM) in coordination with the Joan Oró Foundation and other entities.

The activity 'From Montsec to the universe' (Del Montsec a l'univers) was organised by the representation of the association Women in Aerospace Europe in Barcelona (WIA-E Barcelona) and the IEEC, and was celebrated at the OdM on 6 May, with more than 100 participants (Image 17).

Image 17

During 2023, the usual monthly visits to the OdM were celebrated during the summer season, with a great success thanks to the co-organisation with entities also participating in Joan Oró's year events. These sessions offer the opportunity to take a tour to the Observatory's infrastructure and equipment, such as its astronomical telescopes, satellite communications infrastructure, Earth Observation satellite calibration systems, and atmospheric measurement services. More than 200 people attended the open-visit sessions that were celebrated between May and August.

Image 18

Also, Kike Herrero, director of the OdM, gave a talk about the scientific highlights of the OdM at Dinosfera, in Coll de Nargó (Lleida). This activity, held in collaboration with the Geoparc Orígens on 17 November, was part of the 28th Science Week, organised by the Government of Catalonia and the Catalan Foundation for Research and Innovation.

In the field of education, a visit to the OdM was organised on 18 May for a group of students from Universitat de l'Experiència (UB), on 29 May for the students of Col·legi Claver (Lleida), and on 15 December for a group from the Programa Sènior of Universitat de Lleida. More than 100 students participated in the educational activities at the OdM in 2023.

Finally, it is worth mentioning the recording of the occultation of the star Betelgeuse. One of the brightest stars in the sky disappeared for a few seconds in the early morning of 12 December, as a 65 km diameter asteroid, (319) Leona, passed in front of it. Several IEEC members travelled with equipment from the OdM to near the town of Cieza (Murcia) to record the event (Image 18).

Climate impacts seen from space thanks to Menut

'Menut' is the first Earth Observation nanosatellite of the NewSpace Strategy promoted by the Government of Catalonia.

Developed by Open Cosmos and with the support of the IEEC and the Cartographic and Geological Institute of Catalonia (ICGC), Menut contributes to monitoring and raising awareness of the effects of the climate emergency.

The first images show the effect of the drought situation on the Darnius-Boadella reservoir, located in the Muga basin (Alt Empordà), comparing its state in August 2023 with that of the previous year (Image 19). The loss of water volume can be clearly observed (image on the right), especially in the two tails of the reservoir. In addition, the greater intensity of "colour" in this area indicates an increase in nutrients, proliferation of plant activity and loss of oxygen in the water.

Menut also took an image on 4 September, 24 hours after the passage of the DANA storm over the Terres de l'Ebre, Southern Catalonia (Image 20). Despite the adverse weather conditions, we can appreciate the strong sea storm, the brownish colour of the river and the contribution of sediments to the sea.

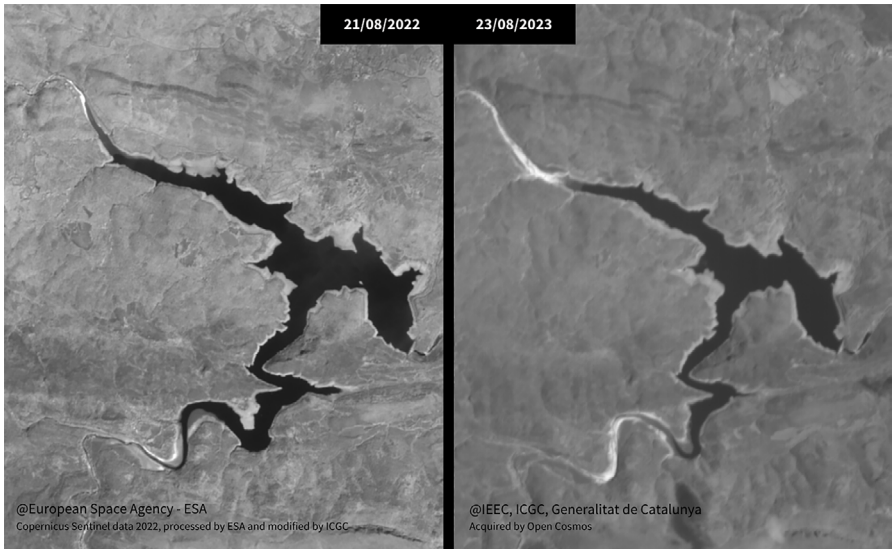


Image 19

Image 20

Event on attracting and retaining talent in the Catalan New Space sector

9 February

On 9 February, an event aimed at providing strategies and resources to the NewSpace ecosystem for the generation, attraction and retention of talent in the territory was held at the Macaya Palace, in Barcelona.

The event was organised by the Digital Catalonia Alliance (DCA) and was supported by the IEEC, the ESA Business Incubation Centre of Barcelona and the Barcelona representation of the organisation Women in Aerospace Europe (WiA Europe - BCN), as well as by “la Caixa” Foundation.

The IEEC celebrated the Women and Girls in Science Day

11 February

The second ‘Day of Girls and Women in Space’ took place on 11 February in the frame of the Women and Girls in Science Day and was organised by Women in Aerospace Europe (WIA-E) in collaboration with the IEEC, at the Balàfia Civic Centre (Lleida). The event had the participation of expert members of the IEEC such as Kike Herrero (Montsec Observatory), Anna Ruiz Ayala (Talent and Society Programme) and Daniel Sors Raurell (Office of Services and Industrial Promotion).

IEEC researchers invite you to visit the cosmos with the series ‘Gravity Land’

20 February

Last 20 February, the documentary series ‘Territorio Gravedad’ (Gravity Land), co-produced by the Instituto de Astrofísica de Andalucía (IAA-CSIC) with the participation of several IEEC researchers at the Institute of Space Sciences (ICE-CSIC) and at the Institute of Cosmos Sciences of the University of Barcelona (ICCUB), premiered on television and platforms. Two presentations of the first episode were held with the filmmakers in Barcelona.

Commemorative Day of the centenary of Albert Einstein's visit

23 February

Organised by the Royal Academy of Sciences and Arts of Barcelona (RACAB), the Commemorative Day of the centenary of Albert Einstein's visit took place on 23 February. This initiative, consisting in a series of talks related to gravitation and relativity, among other topics, had the collaboration of IEEC members as part of the organising committee and as speakers. The event was held in the frame of the 'Biennial City and Science 2023' and also had the support of the Catalan Foundation for Research and Innovation (FCRi).

130 students launched their small satellites in the Catalan qualifying phase of the Cansat competition

29 April

The small satellites built by the participants were launched on 29 April from the Alguaire Airport (Lleida) on rockets designed by the Cosmic Research association. Organised by the School of Industrial, Aerospace and Audiovisual Engineering of Terrassa of the UPC, the event was supported by the Government of Catalonia and the IEEC within the framework of the Talent and Society axis of the NewSpace Strategy.

'La veu còsmica', a podcast combining art and science

8 June

Lluís Galbany, IEEC researcher at the Institute of Space Sciences (ICE-CSIC), joined forces with the poet Esteve Plantada and the musician Joan Garriga to launch an audiovisual podcast that connects art and science. The podcast, available on YouTube, Spotify and Ivoox, features interviews with scientists to bring research in astrophysics and cosmology closer to the general public.

Around fifty youths conquer space with the Scientific Stays of La Pedrera Foundation

2 -7 July

From 2 to 7 July, the Catalunya La Pedrera Foundation brought 45 young people aged between 15 and 17 with an interest in aerospace engineering to Món Sant Benet, in collaboration with the IEEC, GOSTEM and the Government of Catalonia. The 'Scientific Stay – NewSpace: we take off with aerospace engineering' allowed the students to learn, design, build, test, launch and operate two small satellites on technological and scientific missions.

'NewSpace Catalonia' scholarships for the International Space University's SSP 2023 summer programme

26 June - 25 August

In the framework of the objectives of the Talent and Society programme of the NewSpace Strategy of Catalonia, the Government of Catalonia and the IEEC launched a call for 3 scholarships (NewSpace Catalonia Scholarships) to attend the Space Studies Program - SSP. The SSP is an intensive 9-week course organised by the International Space University (ISU) during the summer months, which offers training in a wide range of space disciplines.

The IEEC collaborates in the competition 'Telegram to a Planet'

22 September

The IEEC collaborated in the organisation of the competition 'Telegram to a Planet', which proposes to students from all over Spain (from Secondary Education to High School and Vocational Training) the challenge of composing a graphic message (or pictogram) to establish a first contact with a possible alien civilisation on the potentially habitable planet Teegarden b, located 12.5 light-years away from the Solar System.

SG[Spain] 2023, the annual meeting of young students and professionals in the field of space, held in Castelldefels

17 and 18 November

The Space Generation Advisory Council (SGAC) in Support of the United Nations Programme on Space Applications is a global non-governmental, non-profit organisation and network which aims to connect and represent university students and young space professionals to the United Nations, space agencies, industry, and academia. With the theme 'New dreams, new future, new space', the Spanish regional event SG[Spain] 2023 took place in Castelldefels (Barcelona) on 17-18 November. The event was partially sponsored by the IEEC, in the frame of the NewSpace Strategy of Catalonia.

A project on the expansion of humans to Mars wins the STEAM modality of the 'Ciencia en Acción' contest

30 November

The project 'ARES III: Mission to Mars', developed by 4th year ESO students from Cor de Maria de Valls (Tarragona), received 1st prize in the STEAM modality in the international 'Ciencia en Acción' competition. The project is based on a model of Nüwa, a prototype for a self-sustaining city on Mars led by researchers from the IEEC at the Institute of Space Sciences (ICE-CSIC); the Universitat Politècnica de Catalunya – BarcelonaTech (UPC); and the Institute of Cosmos Sciences of the University of Barcelona (ICCUB), together with the Institute of Marine Sciences (ICM, CSIC).

PhD Theses

PhD THESES

Author — **Pere Gironella Gironell**

Department/Institute — Universitat de Barcelona. Department of Quantum Physics and Astrophysics

Title — Testing the Standard Model with radiative beauty and rare strange decays at LHCb

Date — 28 March 2023

Directors — Carla Marín Benito and Eugeni Graugés Pous

Author — **Xun Duan**

Department/Institute — Universitat Politècnica de Catalunya - BarcelonaTech. Department of Physics

Title — Impulse maneuver design for a solar sail spacecarft in the restricted three-body problem framework

Date — 10 May 2023

Directors — Josep Joaquim Masdemont Soler, Gerard Gómez Muntané and Xiaokui Yue

---

Author — **Paulo Marcos Araujo Da Silva**

Department/Institute — Universitat Politècnica de Catalunya - BarcelonaTech. Department of Signal Theory and Communications

Title — Remote sensing for atmospheric observation and wind energy: over-land boundary layer and off-shore atmospheric stability

Date — 29 June 2023

Director — Francisco Rocadenbosch Burillo

Author — **Andreu Salcedo Bosch**

Department/Institute — Universitat Politècnica de Catalunya - BarcelonaTech.
Department of Signal Theory and Communications

Title — Artificial intelligence, lidar and co-operative remote sensing for atmospheric observation and off-shore wind energy

Date — 30 June 2023

Director — Francisco Rocadenbosch Burillo

Author — **Clara Dehman**

Department/Institute — Universitat Autònoma de Barcelona. Department of Physics

Title — Unveiling the Physics of Neutron Stars - A 3D expedition into magneto-thermal evolution in Isolated Neutron Stars with MATINS

Date — 8 November 2023

Directors — Daniele Viganò, Nanda Rea and José A. Pons

Author — **Diego Cruces Mateo**

Department/Institute — Universitat de Barcelona. Department of Quantum Physics and Astrophysics

Title — Towards a non-perturbative description of cosmological inflation

Date — 13 December 2023

Director — Cristiano Germani

Author — **Marcel Llopis**

Department/Institute — Universitat Politècnica de Catalunya - BarcelonaTech.
Department of Computer Science

Title — Revolutionizing space mission event modeling with the tychonis framework

Date — 14 December 2023

Directors — Javier Franch Gutiérrez and Manel Soria Guerrero

This NASA/ESA Hubble Space Telescope image of the cluster Westerlund 2 and its surroundings was released to celebrate Hubble's 25th year in orbit and a quarter of a century of new discoveries, stunning images and outstanding science.

The image's right region, containing the star cluster, blends visible-light data taken by the Advanced Camera for Surveys and near-infrared exposures taken by the Wide Field Camera 3. The surrounding region is composed of visible-light observations taken by the Advanced Camera for Surveys.

Credit: NASA, ESA, the Hubble Heritage Team (STScI/AURA), A. Nota (ESA/STScI), and the Westerlund 2 Science Team

IEEC

ieec.cat