europlanet Magazine

Issue 5

JUICE

Making history on its way to explore Jupiter's icy moons

ALSO IN THIS ISSUE

- Asteroid Mining
- Live-streaming planetary events
- Policy engagement on the menu
- 'Life Beyond Us' Sci-Fi anthology

State-of-the-Art Labs

Developing facilities that are fit for research that's out of this world

europlanet

The official magazine of Europlanet, the European community for planetary sciences

Since 2005, Europlanet has provided Europe's planetary science community with a platform to exchange ideas and personnel, share research tools, data and facilities, define key science goals for the future, and engage stakeholders, policy makers and European citizens with planetary science. The Europlanet Association promotes the advancement of European planetary science and related fields for the benefit of the community. The Europlanet Society is open to individual and organisational members of the planetary science community.

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Design and artwork Pixooma Ltd

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Take off

Community-building is a major focus for Europlanet in 2023. The Europlanet Research Infrastructure Meeting (ERIM), held in Bratislava in June, was an opportunity to bring old friends and new faces together to discuss the future of the family of Europlanet activities.

The outcomes of ERIM will be used to form a roadmap and operational plan for Europlanet going forward. We are at the early stages of digesting more than 80 hours of discussions, presentations and training from the ERIM programme and will report in more detail about what happened at the meeting in the next issue of the Europlanet Magazine.

Aside from ERIM, there have been multiple Europlanet workshops in recent months that are reported in our 'In Focus' news section. This issue includes a feature on what the JUICE mission will do when it reaches the icy moons of Jupiter in 2031. We look at how Europlanet investments have created and upgraded state-of-the-art laboratory facilities across Europe. Our Planetary Perspectives interview introduces an early career researcher working in asteroid mining. We also find out about how live-streaming, science fiction and games can bring planetary science to new audiences.

Happy summer reading!

Anita Heward
Editor

Contents

In focus

The first half of 2023 has been an intense period of activity for Europlanet and the wider planetary science community. Here, is a roundup of the latest news, meeting reports and results of projects.

Europlanet 2024 RI

Europlanet Research Infrastructure Meeting (ERIM) and EPEC Annual Week 2023

Participants on site at ERIM 2023 in Bratislava. Inset: Participants in EPEC Annual Week

The first Europlanet Research Infrastructure Meeting (ERIM), co-hosted with the fifth Europlanet Early Career Network (EPEC) Annual Week, took place from 19-23 June 2023 in hybrid format at the Hotel Sorea in Bratislava, Slovakia ,and online. 137 participants joined us for the meeting in Bratislava, with a further 94 following the meeting online. Of these, 45 participated in the hybrid EPEC Annual Week training school. Alongside a series of interactive workshops related to the activities of the Europlanet 2024 Research Infrastructure (RI) project, ERIM provided an opportunity to roadmap overall strategy for the Europlanet Society and the new Europlanet Association, a legal structure established to sustain Europlanet programmes for decades to come. The outcomes of the roadmapping exercises will be developed over the coming months, with the aim of publishing a full operational and business plan for Europlanet in September 2024. Look out for a full report on ERIM 2023 in the next issue of the Europlanet Magazine.

https://www.europlanet-society.org/erim2023/

EPSC

Europlanet Science Congress (EPSC) Upcoming Events

Registration is now open for the Joint 55th Annual Division for Planetary Sciences (DPS) Meeting and 18th Europlanet Science Congress (EPSC), which will take place from 1-6 October 2023 in San Antonio, Texas and as a hybrid event online. The conference will be the fourth time the DPS and EPSC have combined their annual gatherings and the second time the joint meeting has taken place in the United States.

New venues have also been announced for the next two EPSC meetings. EPSC2024 will be held at Freie Universität (FU) Berlin, Germany, from 8-14 September 2024. In 2025, EPSC will again be a joint meeting with the DPS, and will take place in the newly refurbished Finlandia Hall, Helsinki, Finland, from 7-13 September 2025.

https://www.europlanet-society.org/epsc/

Top: Banner for DPS-EPSC 2023 Meeting in San Antonio and online. Bottom: Finlandia Hall, Helsinki, Finland, the venue for the EPSC-DPS Joint Meeting in 2025.

Europlanet 2024 RI

Planetary Defence Workshop in Morocco

Planetary defence was the focus of discussion at a workshop in Casablanca, Morocco, held 25-28 April 2023. Over the four days of meetings, dialogue and hands-on training, topics covered included meteorites, meteoroids, impact craters, protection of extraterrestrial material heritage and impact-related astrobiology.

The 'Rocks from Space and Planetary Defence' workshop was the third in a series organised as part of the Global Collaboration and Integration Development Task of the Europlanet 2024 RI project. The series is coordinated by Prof Barbara Cavalazzi, of the University of Bologna, and is designed to promote and and support the development of planetary sciences in Africa - in line with the African Union's objectives for the African Space Strategy. The workshop in Morocco aimed to lay the foundations for forming a community of specialists on planetary defence.

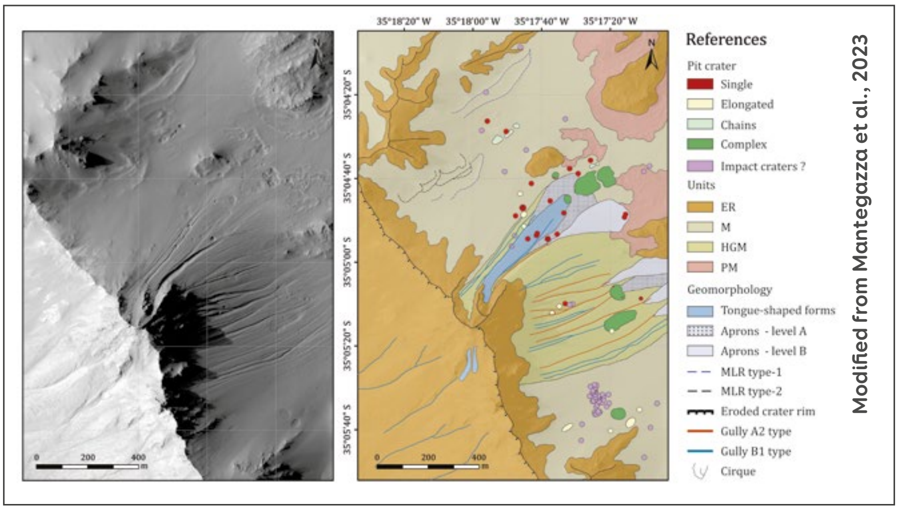
The event was attended by approximately 30 in-person professionals, early career researchers and PhD candidates from all over Morocco (Casablanca, Marrakech, Rabat, Errachidia, Laayoune, El Jadida, Kenitra, Tangier, and Teutan), alongside around 40 international participants who joined online from Africa (Ethiopia, Mozambique, South Africa, Nigeria, Botswana), Europe (Italy, England, Germany), and around the world (China, Jordan, India, Pakistan, Mexico and China).

https://bit.ly/EuroplanetWorkshopSeries

Participants in the Europlanet 'Rocks from Space and Planetary Defence' workshop in Morocco

Europlanet 2024 RI

GMAP Winter School 2023



This analysis of pit craters at Hale Crater, Mars, led by Mara Mantegazza, was supported through the GMAP Winter School.

The third GMAP Winter School was held virtually from 30 January to 3 February 2023. Training sessions were focused on geologic mapping of past and future landing sites on Mars and the Moon, with the aim of highlighting the technical and scientific skills needed for the next generation of planetary mappers. Participants were largely early career scientists, including Master's students, PhD candidates and early post-doctoral researchers. Expanding on the successful format of the two previous editions, with asynchronous interaction as well as live participation in lectures and demonstrations of state-of-the-art techniques, the 2023 Winter School had more than 400 subscribers and 120 real-time attendees during activities. The Winter School was co-funded by the Europlanet-GMAP infrastructure, the University of Padova and Constructor University. Training materials from all Winter Schools to date are available online.

https://www.planetarymapping.eu

Participants in the VESPA Implementation Workshop 2023 in Graz.

Europlanet 2024 RI

VESPA Implementation Workshop 2023

The VESPA Implementation Workshop 2023 took place from 30 May to 2 June 2023 at the Space Research Institute in Graz, Austria. VESPA is a virtual access activity in the Europlanet 2024 Research Infrastructure (RI) programme. Its aim is to make planetary science and Solar System data accessible and searchable through an interoperable system based on the principles of Open Science and standards developed in the framework of the astronomical Virtual Observatory. VESPA currently provides access to 63 data services, with many more in preparation. Five teams, selected through an open call, were invited to attend the workshop to help them design and implement projects to make their data content accessible through VESPA and to open it to the user community. The teams, who came from the Czech Republic, Ireland, Italy and Poland, were joined by Europlanet team members and other database providers. The face-to-face workshop will be followed up by telecons to support the finalisation of the new services, which will be ready in the autumn. https://bit.ly/VESPAWorkshop2023

Europlanet 2024 RI

AQUILA Facility Hosts First Transnational Access Visit

The new Atomki-Queen's University Ice Laboratory for Astrochemistry (AQUILA) facility, established at the ECR Ion Source (ECRIS) Laboratory at Atomki, Debrecen, hosted its first Transnational Access (TA) visit in April. International researchers can now visit the AQUILA facility in Hungary with funding from the Europlanet TA programme.

Grace Richards (front), Dr Richárd Rácz (centre), and Dr Sándor Biri (back) working on depositing an astrophysical ice analogue at the AQUILA facility in Debrecen.

The AQUILA facility consists of an Ultra High Vacuum (UHV) compatible chamber containing a substrate on which astrophysical ice analogues can be grown at cryogenic temperatures down to -253 °C. These ice analogues can be exposed to ion irradiation, and the resultant chemical or physical changes can be monitored using mid-infrared spectroscopy. The new facility has been developed as part of the Europlanet 2024 Research Infrastructure (RI) Joint Research Activity (JRA) programme (see page 28).

The first visit was by Grace Richards, a PhD candidate at the Open University, whose TA project focused on understanding the surface radiation chemistry on Enceladus, an icy moon of Saturn. Europlanet's TA funding covers free travel and accommodation for visiting researchers and service costs for facilities. The programme provides access to over 40 planetary analogue field sites, simulation laboratories and sample analysis facilities.

Since the start of the Europlanet 2024 RI project, three full calls for the TA programme have been issued, as well as a 'fast track' call to support high-impact science and early career research projects. The third and final call, which closed in January 2023, received 108 applications. Following an anonymous peer review, 71 visits were funded, 18 of which relate to planetary field analogue sites and 53 to laboratory facilities. The successful projects include 7 investigations led by researchers from under-represented states and 11 led by international researchers from Asia (Japan, India, South Korea) and America (Argentina, Canada, Ecuador, US). In total, Europlanet 2024 RI has approved funding for 211 research projects out of 322 applications for all calls to date. Summaries of all completed projects can be found on the Europlanet website: https://bit.ly/TAreports

Community

Vision for the Future of European Astronomy Published

A new report by ASTRONET, an international consortium of funders and communities, sets out recommendations to guide investment priorities fostering our understanding of the Universe in the next decades. The ASTRONET Science Vision and Infrastructure Roadmap 2022-2035 is the latest roadmap produced by the ASTRONET network of European funding agencies communities and research organisations.

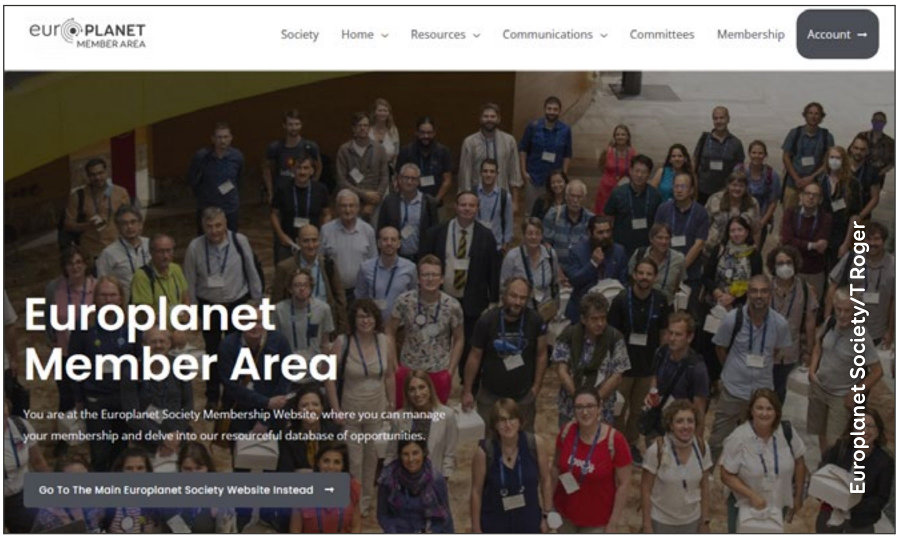
Panels, including over 100 scientists from across Europe, fed into the report and a series of public consultations were also held to ensure that it reflected the breadth of views within astronomy. The overall effort was led by the UK via STFC-UK.

The panels established key science questions, such as understanding the origin of the Universe and the evolution of planets in our Solar System, and made recommendations on the facilities and resources needed to meet these priorities. A continued supply of highly trained and motivated researchers will also be fundamental to progress and societal engagement. In making its recommendations, the report complements recently-published visions provided by the European Space Agency, the US Decadal Survey and advisory bodies, such APPEC for AstroParticle Physics. The previous ASTRONET Science Vision and Infrastructure Roadmap (published in 2007 and revised in 2015) included recommendations that fed into proposals for major scientific infrastructures such as the European Southern Observatory's (ESO) Extremely Large Telescope and the Square Kilometre Array Observatory (SKAO).

https://www.astronet-eu.org

Society

New Website for Europlanet Society Members



Europlanet has a brand new membership website! The site can be accessed from the main Europlanet Society site under the Membership menu item. The new sub-site aims to provide an efficient membership system that integrates many useful tools, such as a newsletter mailing module, payment management, and a platform to edit your details.

The new site also contains members-only resources such as webinars and the Europlanet Industry Database, plus listings of the various committees working within the Europlanet Society and a tool to nominate yourself or a colleague (with their knowledge, of course) for a role in a committee or working group. There is also a space to share opportunities and job openings in the planetary sector.

The Europlanet Executive Office team hopes you enjoy the features offered by this new website. If there is anything you would like to see added or if you have any feedback, please contact:

membership@europlanet-society.org

https://membership.europlanet-society.org/

Switzerland Hub

Incoming Chair of Switzerland Regional Hub

Sascha Quanz is the new Chair of the Europlanet Society's Switzerland Regional Hub. His background is in astrophysics - and specifically in exoplanetary science – and he leads the Exoplanets and Habitability research group in the Physics department at ETH Zurich. The group has a diverse research portfolio ranging from hardware development and instrumentation, to observations, data analysis and modelling of exoplanet atmospheres and interiors. On the hardware side, the group is involved in (large) ground-based and space-based telescopes, such as the Very Large Telescope (VLT) in Chile, the future Extremely Large Telescope (ELT), and the James Webb Space Telescope (JWST).

As Principal Investigator (PI), Sascha is currently leading the international Large Interferometer for Exoplanets (LIFE) initiative. LIFE is an ambitious space mission that will allow humankind to detect and characterise the atmospheres of hundreds of nearby extrasolar planets, including dozens that are similar to Earth. In 2021, the science of the LIFE mission – the characterisation of temperate, terrestrial exoplanets, and searching for life outside the Solar System – was identified as a top-priority theme by a senior committee advising the ESA Science Director, and is a potential topic for a Large Mission in ESA's future Science Programme. Sascha serves on the board of the Swiss National Centre of Competence in Research "PlanetS", an interdisciplinary and inter-institutional research network investigating the formation and evolution of planetary systems, and is the Deputy Director of the recently founded ETH Centre for Origin and Prevalence of Life.

Sascha Quanz, the new Chair of the Europlanet Society Switzerland Hub

Society

The Europlanet stand at Fantasy Basel.

Europlanet Meets Fantasy Basel

With 72,000 visitors, Fantasy Basel is one of Europe's largest science fiction, fantasy and pop-culture conventions.

From 18-20 May 2023, the Europlanet Society joined forces with the NCCR PlanetS and the Swiss Space Museum to highlight the 'science' in science fiction for visitors to Fantasy Basel. The team offered a tour of the Solar System through the 'Planets in a Room' spherical projection kit and a multisensory experience through a collection of meteorites that visitors could look at, handle and – if they so wished - smell. The experience was very much enjoyed by the public as well as the Europlanet team working on the stand, who met some very colourful visitors from across time and universes.

See gallery: https://bit.ly/EuroplanetFantasyBasel

Benelux Hub

Soapbox Science Brussels 2023

Soapbox Science Brussels 2023

On Saturday 24 June, 12 female researchers in Belgium brought their science to the public during the Soapbox Science Brussels event. Soapbox Science is a science outreach initiative that aims to promote the visibility of women and non-binary scientists and their research. The events are based on Hyde Park's Speaker's Corner and aim to transform public areas into discussion forums where scientists, on their 'soapbox' platforms, can talk about their research to people passing by. The organisers of Soapbox Science Brussels include members of the Europlanet Society Benelux Hub. Read more: https://soapboxsciencebrussels.oma.be/

Podcast: PostDoc Life

The latest episode of 'Stairway to Space', the Europlanet Early Career (EPEC) podcast is out now! This episode talks about life as a postdoc and aims to help PhD students interested in starting their career in academia have a clear vision of a postdoc position. The show includes the personal experiences of EPEC members working as postdocs in different parts of the world. The 'Postdoc Life' episode is presented by Safoura Tanbakouei and features guests Iris van Zelst, Ines Belgacem and Solmaz Adeli. Stairway to Space is produced by Ilaria Di Pietro, Foivos Karakostas, Erica Luzzi, Melissa Mirino, Jose Silva, Safoura Tanbakouei, Gloria Tognon and João Dias.

https://bit.ly/StairwayToSpace

EPEC

EPEC profiles are back!

This series introduces members of the Europlanet Early Career (EPEC) community, who share their experiences and aspirations through stories on the Europlanet website.

Submit your profile now:
https://bit.ly/epec-profiles

EPEC

AbGradEPEC 2023 - a Joint Meeting for Early Career Researchers in Astrobiology

After a three-year wait to hold the AbGradEPEC meeting, former AbGradE President, Ruth-Sophie Taubner, and current President, Silvana Pinna, share highlights of the event.

Above: Group photo of participants in AbGradEPEC '23. Top right: Walk to the lava fields of the Cumbre Vieja volcano. Bottom right: Science Speed Dating session.

After years of planning, AbGradEPEC'23 finally took place between 4-6 May 2023, just before the Biennial European Astrobiology Conference (BEACON) on the island of La Palma (Spain). Postponed since April 2020 due to a global pandemic and a volcanic eruption, we were thrilled – contrary to the saying 'anticipation is the greatest joy' – to welcome about 60 attendees to 'La Isla Bonita'. The event was co-organised by Astrobiology Graduates in Europe (AbGradE) and the Europlanet Early Careers (EPEC) Network.

AbGradEPEC'23 kicked off with an ice-breaker, in the evening of 3 May, featuring an astrobiological pub quiz. The following day we opened the meeting with a 'Science speed dating' session, followed by more than 20 keynotes and contributed talks addressing topics such as the 'Limits of life', 'Life on Mars', and 'Prebiotic chemistry'. In the evening, we organised a well-received poster session with 21 posters.

Day two began with a session on 'Astronomy', followed by a workshop from one of our keynote speakers, Nader Haghighipour, who shared insights on 'How to develop a career being an astrobiologist'. In the afternoon, we embarked on an exciting trip to the new lava fields of the Cumbre Vieja volcano, which erupted during the last months of 2021. On the third and final day of our meeting, we started with a workshop on 'Mental Health in Academia', facilitated by psychologist Raphael Taubner, which was followed by an overview by Nigel Mason entitled 'Tips and strategies to survive the academic career'. Eloi Camprubi concluded the meeting with a panel discussion, in which researchers at different stages of their career path shared their experiences.

For many of our attendees, AbGradEPEC'23 marked their first in-person astrobiology meeting ever. We were very happy to provide so many early careers with the opportunity to connect with their peers and have their inaugural 'conference experience' with us. This was only possible thanks to the financial support of the EAI, Europlanet, EANA, and the MDPI-Journal, Symmetry, which enabled us to award more than 30 accommodation grants and poster awards. We look forward to continuing the successful collaboration between AbGradE and EPEC, with hopes of reconvening at the Europlanet Science Congress (EPSC) 2024 in Berlin. https://abgrade.eu

Europlanet 2024 RI

SPIDER Space Weather Service Supports BepiColombo Studies at Venus and Mercury

Europlanet's SPIDER space weather modelling tools have been used in two recent studies, published in Nature Communications, involving flybys by the joint European Space Agency (ESA) and Japanese (JAXA) BepiColombo mission, which is on its way to Mercury.

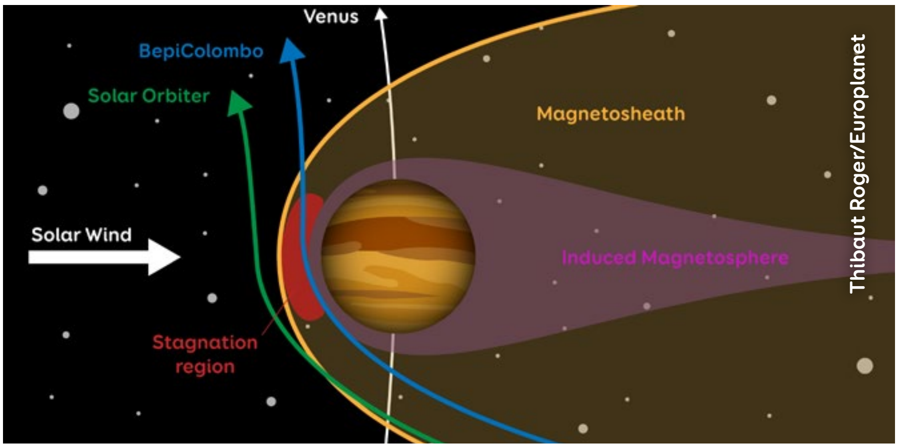
The lead authors of the studies, Moa Persson and Sae Aizawa, both received funding to carry out the research at the Institut de Recherche en Astrophysique et Planétologie (IRAP) in France through the Europlanet 2024 Research Infrastructure (RI) project.

Artist's representation of BepiColombo encountering X-ray auroras at Mercury

The first study, published in December 2022, combined observations of the solar wind by BepiColombo and the ESA/NASA Solar Orbiter, which both serendipitously flew by Venus within a day of each other in August 2021. The flybys resulted in data from eight sensors and two vantage points in space. The results of the study reveal how, without the protection of a global magnetic field, Venus's thick atmosphere avoids erosion by the solar wind.

BepiColombo's flyby of Venus was a rare opportunity to investigate the 'stagnation region', an area at the nose of the magnetosphere where some of the largest effects of the interaction between Venus and the solar wind are observed. The data gathered gave the first experimental evidence that charged particles in this region are slowed significantly by the interactions between the solar wind and Venus.

The observations also showed that the induced magnetosphere provides a stable barrier that protects the atmosphere of Venus from 'stripping' by the solar wind.



Infographic showing the Venus flybys of BepiColombo and Solar Orbiter. The Venus flyby occurred during remarkably stable and quiet solar wind conditions, in contrast to high-pressure solar wind conditions observed during the Mercury flyby.

The second study, published in July 2023, relates to BepiColombo's first flyby of Mercury on 1 October 2021. Analysis of data from three of BepiColombo's instruments during the encounter has revealed how electrons raining down onto the surface of Mercury can trigger high-energy auroras.

The study revealed how high energy electrons are transported from the tail region of the magnetosphere towards the planet, where they eventually rain down on the Mercury's surface. Unimpeded by an atmosphere, they interact with material on the surface and cause X-rays to be emitted, resulting in an auroral glow. The study also confirms that the mechanism that generates auroras is the same throughout the Solar System.

Together, the studies demonstrate how turning sensors on during planetary flybys and cruise phases can lead to unique science.

Persson et al. DOI: 10.1038/ s41467-022-35061-3

Aizawa et al. DOI: 10.1038/ s41467-023-39565-4

Fourth Fireball Forum

Günter Kargl and Manuel Scherf (Space Research Institute, Austrian Academy of Sciences) describe the outcomes of a series of workshops on fireball detection organised through the Europlanet 2024 Research Infrastructure (RI) project.

Banner for the final Europlanet Fireballs Workshop.

Since 2021, Europlanet has organised four workshops on the topic of monitoring fireballs. Fireballs are meteors, brighter than the planet Venus, that streak across the sky. Multiple camera networks, run by amateur astronomers and some professional institutions, have been set up to observe and monitor the phenomena around the world. The aim of the workshop series has been to bring together fireball observers and machine-learning experts to share knowledge and develop common tools.

At the first workshop, held in June 2021, camera data was presented from three networks that were used to find the Winchcombe meteorite that landed in the UK on 28 February 2021. To compare the data, a significant investment of time was needed to make the different data formats of the networks involved compatible. Discussions in the workshop opened up the possibility of having a common (or at least an open exchange) format to speed up the process for combining data and analysing the path of the fireball. The capacity to do this quickly can increase the probability of finding meteorite fragments and to preserve them for science before professional meteorite hunters can have a chance to collect them for commercial purposes.

Over the last two years, two more workshops have been held and a common data format has been identified and further developed. The system is based on a preliminary format, developed at the University of Aberystwyth during a previous Europlanet EC-funded project, that complies with standards for making data available in the virtual observatory for planetary data, VESPA.

Updates at the final workshop, held on 12-13 May 2023, showed that five major networks have implemented this new format and a further network is considering whether they have the available personnel resources to implement it too.

The workshop series was organised in collaboration with the ESA Space Situational Awareness (SSA) office. Three of the four meetings were held as virtual events, enabling participation from all over the world including from Europe, USA, India, Brazil, Columbia, Morocco and a very large involvement of Australia and New Zealand (Desert Fireball Network).

As well as providing a forum for discussion, the workshops have included opportunities to disseminate relevant resources, including machine learning tools for fireball detections. Lunar impact flashes were also discussed and were the main topic of the final workshop. Hands-on training in an ESA software package for detecting lunar impacts was provided.

Presentations from the four workshops will remain available online as an ongoing resource for the community.

https://bit.ly/EuroplanetFireballWS

NASA/Goddard/U Arizona

Planetary Perspectives: A Planetary Scientist Turned Asteroid Miner

This edition's 'Planetary Perspectives' interview with Dr Lauri Siltala has been contributed by J D Prasanna Deshapriya, Hans Huybrighs, Peter McArdle, and Ottaviano Rüsch of the Europlanet Early Career (EPEC) Future Research Working Group. It is the latest in a series of conversations by EPEC, 'Industry or Academia?', which aim to gather insights from people who have had success in both sectors.

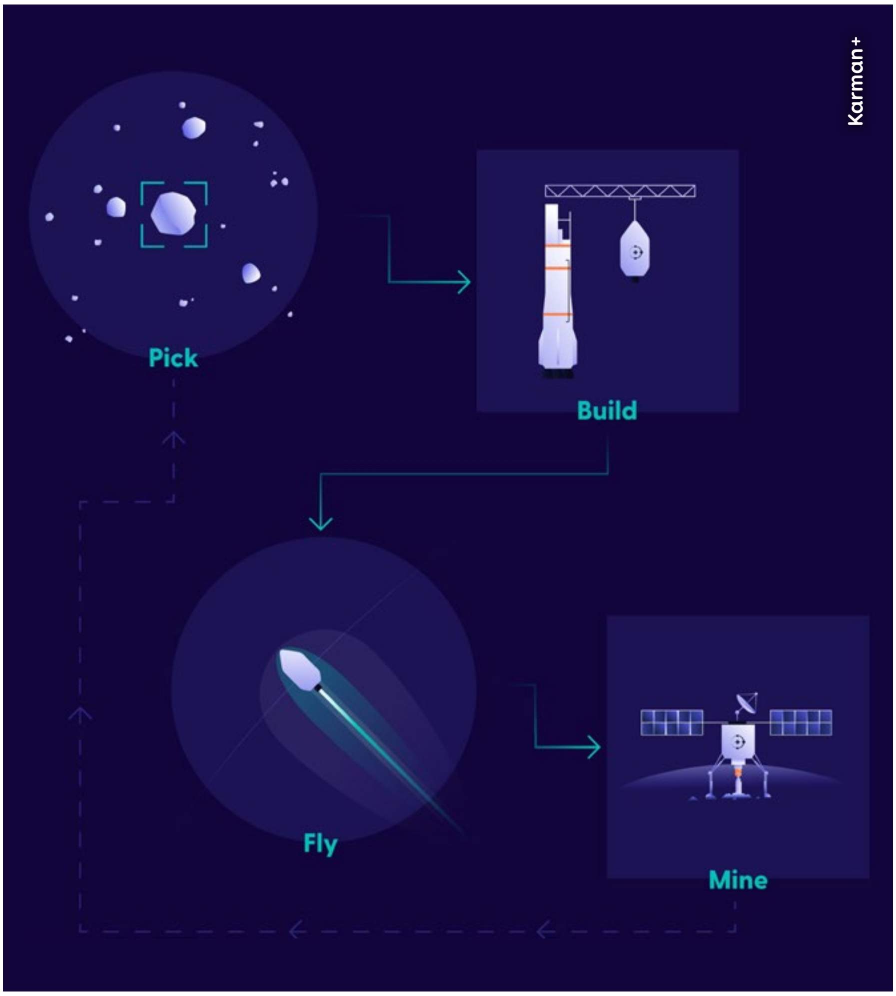
Asteroid mining is an exciting field in the exploration of space. Confined to the realm of science fiction until recently, it is now the central idea of multiple start-up companies. As planetary scientists, we've been wondering what the advent of asteroid mining will mean for our research field and whether it could produce new job opportunities for us. We spoke to Dr Lauri Siltala, a planetary scientist working for Karman+, one of the start-ups aspiring to make a breakthrough in asteroid mining. Lauri tells us that, currently, observational astronomy is a key skill that asteroid mining companies are looking for – and that the set of desirable planetary science skills will keep growing!

Could you tell us about your career as a planetary scientist and how it got you to your current job?

I completed my PhD in astronomy at University of Helsinki in December 2021. Since then, I have been working as an asteroid characterisation specialist at Karman+, an asteroid mining start-up company. In my role, I assess possible target asteroids for the mining operations of the company. I have had a long-term interest in asteroid mining and was fortunate enough to be in the right place at the right time. Towards the end of my PhD, my advisor was contacted by Karman+ regarding a science project. He put me in touch with

L.Siltala

The Karman+ team, with Lauri on the left.



The Karman+ roadmap is to pick an asteroid, build a spacecraft, fly to the asteroid, mine the minerals and fly back. The idea is not to do this once, but a million times!

them and, after a short application process, I was hired! Karman+ was based in Europe but recently moved to the US due to a more favourable legal and economic environment for space mining companies. However, I have the flexibility to work remotely from home in Finland. Currently, I am the only planetary scientist in the company, which is made up of seven other employees.

Which planetary science skills will be most relevant for the field of asteroid mining?

At present, the most relevant skills are those linked to the observational astronomy of asteroids, such as spectroscopy, interpreting light curves and shape modelling. In the future, asteroid mining missions will likely require a variety of instrumentation, so a wider variety of planetary science skills will be needed. Some of those skills will be remote sensing and analysis of in-situ samples. Asteroid science is a very large field and it is unlikely that asteroid mining companies will have all of the planetary science skills in-house. Instead, I expect that the asteroid mining industry will rely on academia to cover some of the fields. We are already seeing close collaborations develop between the asteroid mining industry and academia.

What advice do you have for early career planetary scientists who are interested in joining the asteroid mining industry?

Asteroid mining is a relatively young industry and, so far, none of the asteroid mining companies have succeeded. Although asteroid mining is a risky business, it is an exciting field to work in. I am confident that Karman+ will succeed because of its key success drivers: pragmatism and focus. As with many other industries, networking has been a key factor in my own success. Attending conferences and space industry events, as well as directly contacting prospective employers, are all ways in which early career scientists should aim to build up a network.

Is going back to academia an option from your current position?

My current role allows me to publish research in academic journals and I am also maintaining my ties with academia as a visiting researcher at the University of Helsinki. So, I expect that it would be possible for me to return to academia in the future, should I want to.

Conclusion

Asteroid mining is a developing industry with many exciting possibilities. This industry comes with some risk for those aspiring to a career in asteroid mining. However, as Lauri reports, it is a great field to work in, with a combination of exciting scientific and technical work, flexibility and the opportunity to be part of a revolutionary new industry. As with many careers, development of key skill sets and a network of contacts will be critical for early career researchers hoping to pursue a career in this exciting industry. With the potential for growth, this industry could become a major employer of planetary scientists in the future.

Find out more about Karman+ at: https://karmanplus.com
Read other 'Industry or Academia' Interviews at: https://bit.ly/IndustryOrAcademia

Policy Engagement on the Menu

Members of the Europlanet Policy and Industry Team and Executive Board reflect on recent activities by Europlanet to engage with policy makers.

The Europlanet Industry Officer, Marcell Tessenyi, participates in the Dinner Debate at the European Parliament in January 2023.

Europe has world-leading programmes covering all areas of space activities, and the largest international community of planetary scientists.

Alongside governmental spending on space, interest and investment from the private sector are increasing. However, while Europe has enormous potential in this area, it lacks a common policy framework, legislative basis, and overall Space Strategy. If Europe is to fully exploit the resources at its disposal, it needs to build a coherent, well-networked and collaborative space community.

To discuss the importance of a European Space Strategy, the status quo and common visions, Europlanet and Niklas Nienass MEP co-hosted a Dinner Debate in the European Parliament on 24 January 2023. This high-level event brought together decision-makers, academics and researchers to discuss the theme of *'Promoting the Importance of Space Policies and a European Space Strategy'*.

The evening started with an introduction by Niklas Nienass, Member of the European Parliament (MEP) for the Greens/European Free Alliance Group. A strong supporter of the European New Space economy, Mr Nienass sits on the European Parliament's Committee on Industry, Research and Energy (ITRE), and is committed to establishing European space legislation and setting international standards for space traffic management.

Europlanet's President, Prof Nigel Mason, who was unable to attend in person, welcomed the participants and contributors through a pre-recorded video address. To set the scene for the debate, Prof Mason highlighted the importance of the

Left: Niklas Nienass, MEP, introduces the Dinner Debate. Right: Josef Asbacher, Director General of ESA, takes part in the discussions.

European Union's Horizon programme to underpin basic research and support a growing space industry that can provide new technology and industry opportunities for the benefit of humankind.

The event started with a few invited introductory statements by guests, including: Marian-Jean Marinescu MEP; Rodrigo da Costa, Head of the EU Agency for the Space Programme (EUSPA); Josef Aschbacher, Director of the European Space Agency (ESA); Kai-Uwe Schrogl, President of the International Institute of Space Law (IISL) and Special Advisor for Political Affairs at ESA; Christoph Kutz, Head of the Directorate-General for Defence Industry and Space (DG DEFIS); and Charles Galland, Policy Manager at ASD-Eurospace.

An open debate followed, in which topics and ideas discussed included:

- The positioning of the European space industry within the global space race.
- The topic of policy and space law, particularly the challenge of regulating space at national and European level.
- Sustainability and how space applications can support greener policy.
- Benefits and challenges for a common European space strategy and policy.
- Collaborations between academia and industry as well as the contribution of the scientific/academic community to the development of space technology/industry in Europe.
- Addressing the lack of competition and strategy in growing the European launcher industry.
- Resilience, core interests and factual needs in these turbulent times.

Ann-Carine Vandaele, President Elect of the Europlanet Society, highlighted that science also needs access to space within the framework of the private sector and international and national agencies. The scientific community and Europlanet need to ensure that the scientific use of space is something that is considered in high-level policy making.

In addition to organising the Dinner Debate, Europlanet has sought opportunities to collaborate with other organisations that have similar aims and objectives in engaging with policy makers. In November 2022, representatives from Europlanet attended a dinner debate on Space Traffic Management, part of the 'Making Space Matter' initiative that Friends of Europe is running in partnership with the European Space Agency (ESA).

In the last week of February, Europlanet also supported the European Astronomical Society (EAS), the European Southern Observatory (ESO) and ESA in holding a week-long exhibition in the European Parliament and an event on the theme *'Are We Alone in the Universe? Understanding Exoplanets'*. The activities were hosted by Lina Galvez Muñoz MEP and attended by officials, MEPs and their staff.

Ms Muñoz, alongside EAS President Roger Davies, chaired an afternoon of presentations and a panel discussion on 28 February, which was followed by an informal drinks reception. Speakers included Francesco Pepe from Geneva Observatory, Laura Kreidberg from the Max Planck Institute for Astronomy in Heidelberg, Mariya Lyubenova from ESO and Theresa Lueftinger from ESA. The Europlanet Society Treasurer, Didier Moreau, of the Royal Belgian Institute for Space Aeronomy (BIRA-IASB), kindly contributed a collection of meteorites to the exhibition and was present throughout the week to offer MEPs, members of staff and visitors to the Parliament an opportunity to handle rocks from space.

A clear message from all these activities is that organising and participating in direct opportunities to engage with policy makers are an important part of Europlanet's sustainability strategy. To ensure that our community's voice continues to be heard at the highest level, we need to work closely with related networks and organisations. Within our own community, we also need to broaden the pool of representatives that we can draw on who feel confident to participate in policy discussions. Starting with the recent policy session at the Europlanet Research Infrastructure Meeting (ERIM) 2023, a priority will be to provide training and resources to share best practice in engaging with policy makers. Developing this expertise in the community is an important step to help us maximise the impacts of planetary science and ensure that they are recognised by all European Citizens.

Find out more: www.europlanet-society.org/policy-industry/policy/

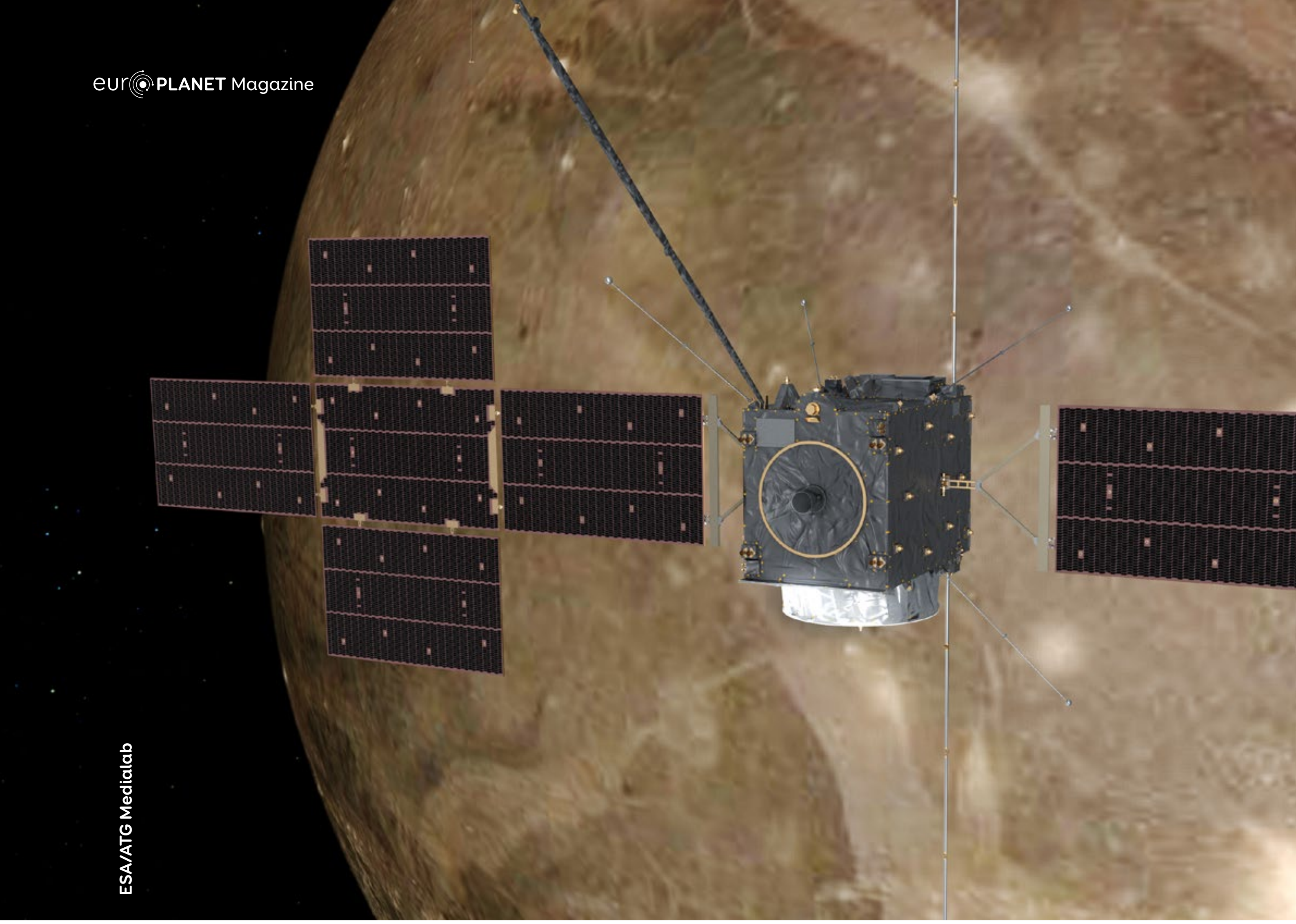
Top: The Europlanet Dinner Debate at the European Parliament on 24 January 2023. Bottom Right: Approaching the European Parliament in Brussels. Bottom Left: Participants in the Dinner Debate gather in front of the entrance to the European Parliament.

ESA's JUICE Mission

Making History on its Way to Jupiter

Athena Coustenis (CNRS/Observatoire de Paris, Meudon, France), member of the JUICE Science Working Team and Co-I of the JANUS camera, describes the emotional journey to the launchpad and beyond for Europe's new mission to explore the icy moons of Jupiter.

ESA's JUICE mission blasts off on its journey to explore the icy moons of Jupiter.



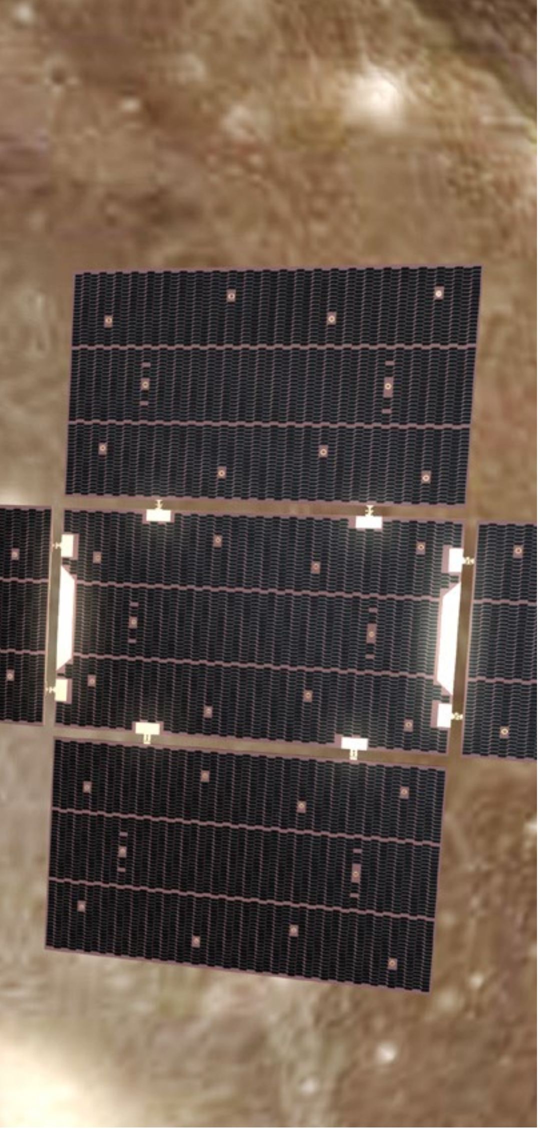
Artist's impression of JUICE making a flyby of Jupiter's largest moon, Ganymede.

The JUpiter ICy moons Explorer (JUICE) launched on Friday, 14 April 2023 at 14:14 CEST (9:14 AM local) from the European Space Agency (ESA) spaceport in Kourou, French Guiana.

I was very happy to witness the launch on site, from the Toucan Observation Deck, alongside many of the friends and colleagues with whom I started this adventure more than 13 years ago. We all watched in awe as one of the very last Ariane 5 launchers lifted the spacecraft, which had a launch-mass of 5.963 tonnes, from pad ELA-3. The 116th Ariane 5 mission flew due east out over the Atlantic Ocean and inclined just shy of three degrees to the Equator. At three minutes and nine seconds (T+3:09) into the flight, the fairings separated to reveal JUICE in its stowed-configuration. The upper stage separated from the core stage at T+8:44 and five seconds later, after a very short coast phase, the upper stage's HM-7B engine ignited. This burn pushed JUICE to a speed of 2.5 kilometres per second, giving the spacecraft enough energy to escape the Earth-Moon system. The upper stage shut down at T+25:25, with spacecraft separation occurring shortly after at T+27:45.

To our relief, after some very long, nervous minutes watching the screen, first contact with JUICE was achieved. About an hour later, the communications antenna, followed by the 85-square-metre solar arrays – the largest solar panels ever flown on an interplanetary spacecraft – deployed perfectly. JUICE was safely on its way! Over the following hours, days and weeks, JUICE deployed various antennae, a magnetometer and probes for measuring its gravitational, radio, plasma and magnetic environments. A sticky situation with the 16-metre-long Radar for Icy Moon Exploration (RIME) antenna, which jammed mid-way through unfolding, was resolved eventually by firing two actuators that jolted the final pieces into position.

The successful launch was an emotional moment because the story of JUICE started with a setback: in 2011, the Europa Jupiter System Mission (EJSM), a proposed joint NASA-ESA mission to study Jupiter's and magnetosphere, was abandoned due to constraints with the NASA budget. However, along with many other colleagues, Michele Dougherty, Emma Bunce, Olivier Grasset, Christian Erd and I recovered the proposed Ganymede orbiter from EJSM and turned it into



the first large mission to fly within the European Space Agency's Cosmic Vision 2015-2025 plan.

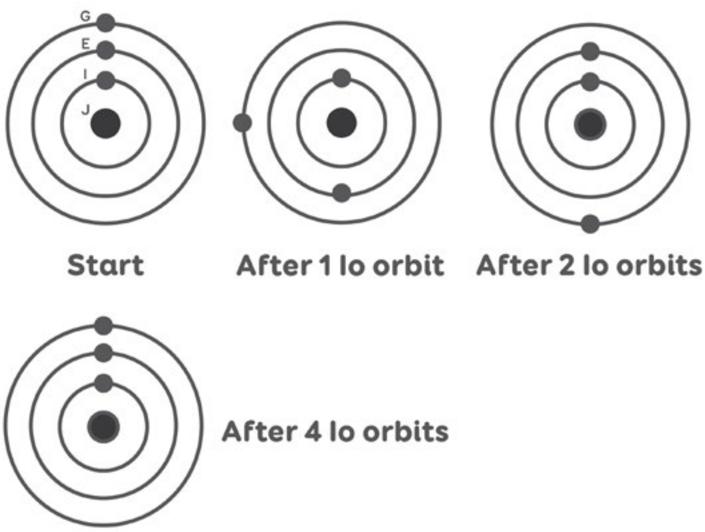
The high-level goal of JUICE is to investigate the largest planet in our Solar System, Jupiter – its magnetosphere, its icy moons and their inter-relations in all their complexity – through detailed observations with a suite of ten unique instruments. However, the main focus of the mission will be on the three large 'Galilean' moons, Ganymede, Callisto and Europa, that are expected to harbour liquid water oceans underneath their surfaces. JUICE will characterise these moons, highlighting their unique features as planetary objects, and investigate their astrobiological potential as possible habitats. The mission will also explore Jupiter's complex environment in depth and study the wider Jovian system as an archetype for gas giants in other exoplanetary systems across the Universe. JUICE will arrive at Jupiter in mid-2031, with a mission duration foreseen until at least 2035. It is a 3-axis stabilised spacecraft that uses a set of spinning momentum wheels to adjust its orientation and a propulsion system to adjust its attitude and orbit. A series of Venus and Earth gravity assists will speed JUICE onwards during its 8.9-year cruise.

JUICE will be the first spacecraft ever to orbit a moon other than our own – Jupiter's largest moon, Ganymede. And, en route to Jupiter, it will perform the first ever lunar-Earth gravity assist – a flyby of the Moon followed a day and a half later by the Earth – which will save a significant amount of propellant.

The mission will culminate in a dedicated nine-month orbital tour around Ganymede, during which the spacecraft will perform an in-depth investigation of the moon and its environment. During this phase, JUICE's orbits will include an elliptical phase, followed by a circular orbit at a 5000 kilometre altitude above Ganymede's surface, then a second elliptical phase. A final manoeuvre will put the spacecraft into a circular orbit at a 500 kilometre altitude. A mission extension, through continued operations at the final or at a lower orbit (target 200 kilometres), may be feasible depending on the propellant usage and the performance of the solar arrays and the overall spacecraft.

Once its mission ends, JUICE will eventually impact the surface of Ganymede to ensure that it does not collide with Europa and potentially contaminate it with microbes from the Earth carried by the spacecraft.

The science objectives for JUICE cover a broad range of different disciplines and call for a large number of measurements. JUICE will carry out extensive new studies of Jupiter's atmosphere and magnetosphere – and their interaction with Jupiter's moons – to enhance our understanding of the evolution and dynamics of the Jovian system. The mission will characterise the diversity of processes in the Jupiter system that may be required to provide a stable environment at the icy moons over geological time scales. This includes gravitational inter-relationships between the Galilean satellites, and their long-term tidal influence on the system as a whole. Ganymede, Europa and Io exhibit a 1:2:4 'Laplace resonance' (below), whereby Io, the closest planet to



Ganymede,Europa and Io are locked in a 1:2:4'Laplace resonance', whereby Io orbits four times for every two orbits of Europa and one orbit of Ganymede.

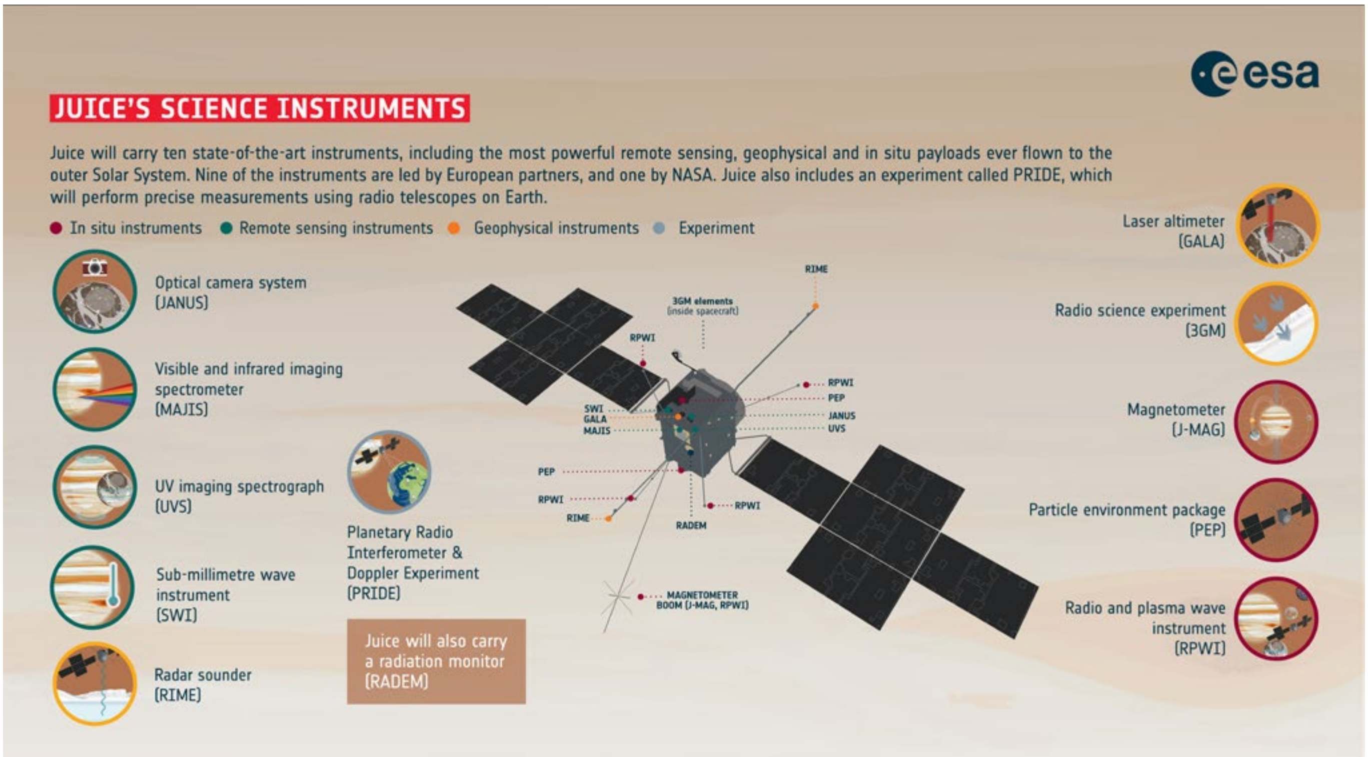
From left to right: With Josef Aschbacher (ESA DG) and Daniel Neuenschwande (Director, Space Transportation) on site at Kourou in the Jupiter Hall before the launch; With Hauke Hussmann (JUICE GALA PI), and Paul Hartogh (SWI PI); With Claire Vallat (Operation Scientists for the JUICE mission); With PIs and Team Members of the MAJIS instrument and Günther Hasinger, former ESA Science Director.

Jupiter, orbits four times for every two orbits of Europa and one orbit of Ganymede. JUICE's studies of Ganymede, Callisto and Europa will be enhanced by additional remote-sensing data gathered on Io and the smaller moons.

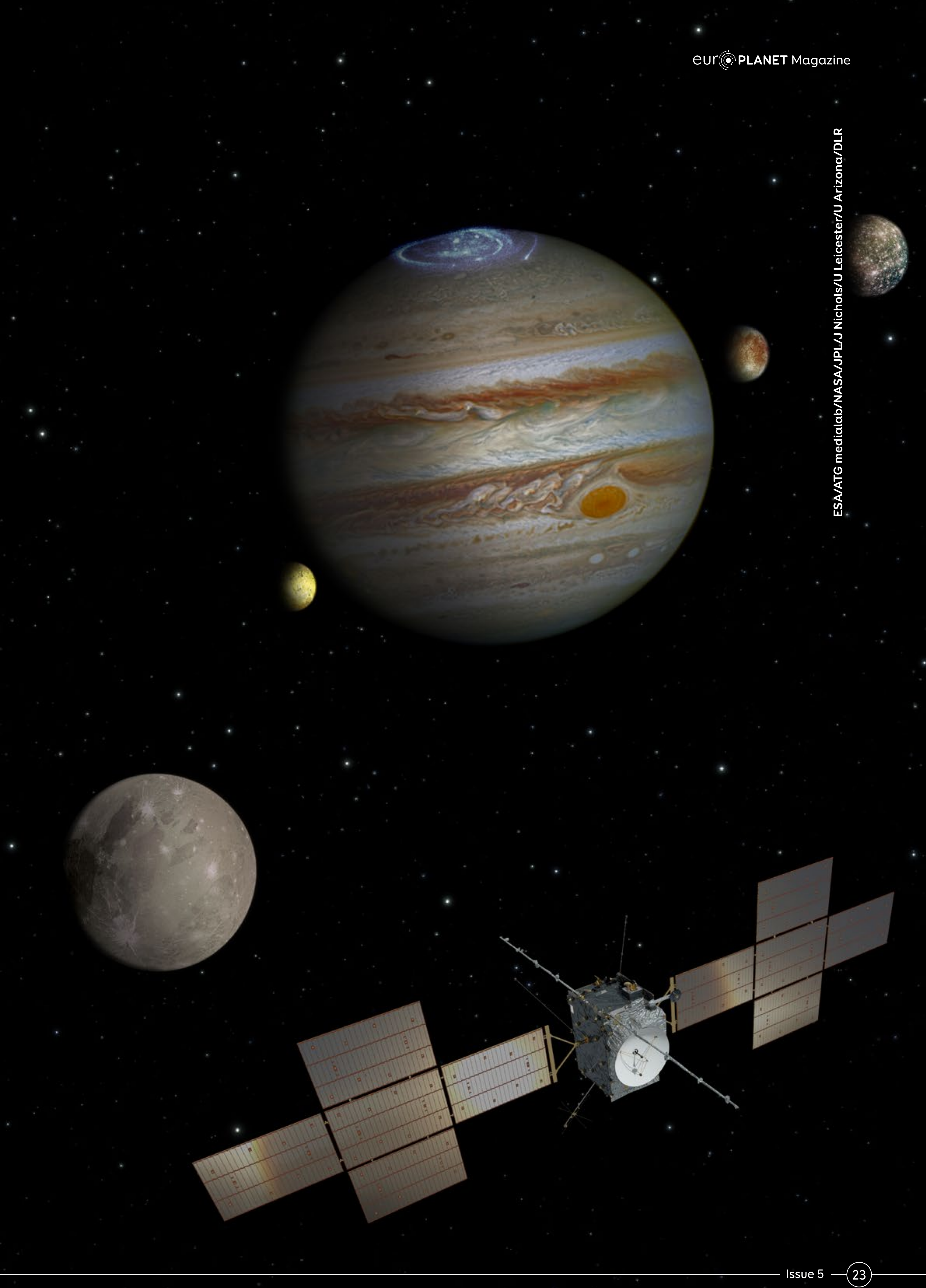
The tidal response of the moons' icy shells strongly depends on the presence of oceans. The Galilean moons are locked in a stable 1:1 spin-orbit resonance (i.e. like Earth's moon, they rotate once for every orbit). However, slight periodic variations in the rotation rate (physical librations) and the amplitudes associated with these librations may provide further evidence for subsurface oceans. JUICE will precisely measure the rotation rate, pole-position, obliquity (tilt) and libration amplitude of Ganymede. This will further constrain the dynamical history of the moon (e.g. despinning, resonance capture, non-synchronous rotation of the icy shell), as well as yielding information on the subsurface ocean and deeper interior.

Ganymede, the largest natural satellite in the Solar System, became the main target of this space mission not only because it provides a natural laboratory for the investigation of a possible habitable world, but also because of its unique magnetic and plasma interactions with the surrounding environment, and because of the role it plays with the other Galilean satellites within the Laplace resonance.

Ganymede and Europa are believed to be internally active, due to a strong tidal interaction and other energy sources. The instruments on board JUICE will investigate the evolution and chemical composition of the icy moons' surfaces and



JUICE's payload of science intstruments



ESA/ATG medialab/NASA/JPL/J Nichols/U Leicester/U Arizona/DLR

Ready to go!

Waiting for take-off on site...

JUICE just left! Happy...

of their subsurface oceans. The studies of subsurface liquid water oceans in several of these bodies will lead to a better understanding of their chemical composition and the possible sources and cycling of chemical and thermal energy. JUICE will also provide the research community with detailed information on how gas giants and their moons form and evolve, and will enable an evaluation of the processes that have affected the moons and their environments through time.

The JUICE spacecraft carries remote sensing, geophysical and in-situ instruments that are engineered to the specific challenge of taking measurements in Jupiter's intense radiation environment. The payload (see infographic on page 22) consists of ten state-of-the-art instruments and one experiment that uses the spacecraft telecommunication system with ground-based instruments. This suite of instruments involves people from many different countries and areas of expertise, who represent large scientific and engineering communities and demonstrate the broad international collaboration around the project.

The remote sensing instruments include capabilities for imaging (JANUS) and spectral-imaging from the ultraviolet to the sub-millimetre wavelengths (MAJIS, UVS, SWI). The geophysical package consists of a laser altimeter (GALA), the radar sounder (RIME) for exploring the surface and subsurface of the moons. A radio science experiment (3GM) will probe the atmospheres of Jupiter and its moons, and perform measurements of the gravity fields. A further experiment (PRIDE) will use ground-based very-long-baseline interferometry to precisely determine the spacecraft's position and velocity for complementary gravity science. Finally, particle and field investigations will be performed by the particle environment package (PEP), a magnetometer (J-MAG), and a radio and plasma wave instrument (RPWI), which includes electric field sensors and a Langmuir probe for measuring the the electron temperature, the electron density and the ion density of the plasma.

As with previous endeavours of this magnitude, JUICE is an international mission. NASA has contributed the UVS instrument and hardware for two European-led instruments, while the Japanese Space Agency (JAXA) has contributed hardware for various of the European-led instruments.

The fascinatingly complex system around Jupiter makes it a priority target for space missions and ground-based observations. NASA's Juno mission, which arrived in 2016, is carrying out a focused study of Jupiter's interior and inner magnetosphere that will be complemented by the in-situ characterisation of the wider Jovian system by JUICE, as well as NASA's upcoming Europa Clipper mission.

JUICE and Europa Clipper will certainly provide original and ground-breaking results, including on Jupiter's atmosphere, magnetospheric and plasma environment, as well as on the exospheres of the icy moons. Having two spacecraft at the same time around Jupiter will also improve the accuracy of data on positions over time (ephemerides) of the Galilean moons, thus enhancing our knowledge of the dynamics, resonances and internal dissipation in the Jovian system.

I would like to say a huge thanks to the whole JUICE team: Olivier Witasse, Giuseppe Sarri, Nicolas Altobelli, Claire Vallat and everyone working on this mission for the past 13 years! I'm looking forward to getting a glimpse of the arrival in mid 2031 and to the joint observations and many breakthroughs from the JUICE and Europa Clipper missions to come!

Find out more:
https://bit.ly/JUICEmissionESA

A Guide to Live-Streaming Astronomy Events

Claudia Mignone (INAF), Anne Buckle and Graham Jones (timeanddate.com) and Helen Usher (Open University) share tips for a new era of astronomy live-streaming.

Left and Right: In the field with Go Stargazing in the UK. Middle: Federica Duras, of the National Institute for Astrophysics in Italy, presents the "Il cielo in salotto" live-stream.

In normal times, we carry on with our busy lives, mostly oblivious to the beauty of the night sky and the dance of stars and planets unfolding above our heads.

But in 2020, a dangerous virus was spreading rapidly around the world, leaving most people with no choice but to shelter at home. In those scary and emotional weeks at the start of the Covid pandemic, people started taking more notice of the celestial bodies and their regular motions across the heavens.

From our windows, terraces, and any available peepholes, we watched the Moon, gazed at the starry sky, and searched for the International Space Station zipping overhead. Even a great comet, C/2020 F3 (NEOWISE), made an appearance to encourage us to cast our eyes upwards.

With people more engaged with heavenly phenomena than usual and public observatories closed to visitors for months - or even years - astronomers rose to the challenge. Our community harnessed the power of the Internet and we entered a new era of astronomy live-streaming.

There had already been some experimentation with this format but, in 2020, interest accelerated. A growing number of professional and amateur groups around the world became involved with live-streaming astronomical events to the general public.

As the pandemic slowly evolved into the "new normal", work did not stop. The livestream format has been revamped to engage people, spread across different regions and countries, with the wonders of the Universe. It has provided new ways of connecting with parts of society facing barriers to participation in astronomy, such as people who may be reluctant or unable to participate in late-night astronomy events in remote areas.

How has the public reacted to this bounty of astronomy coming straight to their preferred digital device? Will the hype continue? How can astronomers and content-creators

Left: Backstage view at INAF's "Il cielo in salotto" live-streaming. Middle: Details on the surface of the Moon observed during the 'SuperMoon' livestream in May 2021 from the astronomical observatory in Palermo, Sicily. Right: Preparing for the livestream of the 'SuperMoon' at the astronomical observatory in Cagliari, Sardinia.

keep producing these live-streamed events sustainably?

Based on our own experiences streaming astronomical events for timeanddate.com, Europlanet and the Italian National Institute for Astrophysics (INAF), we wanted to discuss some of these questions. We convened a session at the Europlanet Science Congress (EPSC) 2022 in Granada, Spain, on 19 September 2022. This session sparked a conversation that continued, during a follow-up workshop on Zoom on 23 November, to engage with an even larger and more widely spread group from Australia, Canada, Chile, Germany, Greece, Italy, Norway, Spain, Turkey, the UK and the US.

Here, we share some of the main learning points from these discussions:

Should I stream or should I not?

Many agree that astronomical events - comet appearances, lunar or solar eclipses, conjunctions or alignments - are definitely worth live-streaming if the media is talking about them. The rarer an event, the more powerful the media hook. However, some "evergreen events" can work well for every season, like the (in)famous "SuperMoon". Once an audience is engaged with an event, then this hook can be used to talk about the underlying science or the behind-the-scenes work of astronomers. Topics in the school curriculum can be used to engage students and educators, even if the event is in the middle of the night (teachers can show recordings at school on the following day).

Connecting live observations to science offers multiple possibilities. Lunar eclipses, for example, work as a proxy to talk about exoplanets: astronomers sometimes do spectroscopic observations during the totality phase of an eclipse, since the Moon is illuminated by sunlight that has been filtered by Earth's atmosphere. Using these observations to look for biomarkers in the spectrum can work as a benchmark to explain transit spectroscopy of exoplanets.

Are we reaching our audience?

The measurement of engagement, retention, and impact of a live-stream depends on the audience. Some teams have big audiences – for example timeanddate.com or NASA - while others have a more accessible, local audience. Language also matters: events streamed in global languages can reach across the planet, but deeper engagement works best in the local languages, especially when trying to engage schools or informal audiences. The better an audience is known and understood, the easier it can be retained - bigger audiences tend to lead to quantitative results, smaller ones to qualitative results. A combination of both these outcomes is the ideal. Some of the methods used to maximise engagement and retention are:

- social media chats before, during and after the event;
- live updates, e.g. via a blog;
- calls to action, e.g. asking people to upload images via Flickr and other online platforms;
- building an email database and using newsletter services to reach people (e.g. Mailchimp);
- providing simultaneous translation to reach all audiences.

Methods for measurement can range from media mentions to likes, shares, reactions and comments on social media, or from surveys to audience-retention analytical data on YouTube.

From live-streaming to in-person stargazing

Balancing large audiences with engaging content is not a trivial challenge. Interactivity can enhance impact and can lead to potential further engagement, though it is not fully clear how to implement this in

Left: Neill Sanders, the founder of Go Stargazing in the UK, captures a solar eclipse for timeanddate.com in June 2021. Middle: The timeanddate.com mobile observatory captures an eclipsed moonset over the Sahara desert in May 2022. Right: The 'SuperMoon' observed during the July 2022 "Il cielo in salotto" livestream from the observatory in Cagliari, Sardinia.

live-streamed events. Sometimes the need arises to manage expectations about what can be actually seen during the event. In this case, having an experienced presenter can give viewers a more personal exploration and help interpret what is being observed. From experience and feedback, it appears that providing context is a key element for the audience: adding background information about what they are seeing, why it is important, and the underlying science.

The pandemic triggered renewed interest in the night sky, drawing large audiences towards live online events. However, nothing beats the experience of peering through a telescope eyepiece for the first time! People should always be encouraged to enjoy and understand the real sky above them, especially during special events. Why watch an eclipse online when you can go outside and see it in the sky? Nonetheless, in many cases – and not just during a pandemic – an in-person visit to a local observatory is simply not possible, so live-streaming can open up new public engagement opportunities across space and time. Hybrid viewing can also work well: setting up screens to show live views (via Electronically Assisted Astronomy), alongside telescope viewing, has proved helpful in managing queues and keeping up the interest during public events.

Building a network for live astronomy events

When inviting people to watch the sky, it is helpful to prepare and provide supporting materials, e.g. star maps. Online events should include a call to action, such as encouraging viewers to find their local astronomy club or visit an observatory. Our experiences highlight how crucial it is to build local as well as national and international collaborations, linking with local astronomy societies and national federations. A live calendar of astronomical events can be a helpful tool to remind people about upcoming highlights and encourage them to go outside and stargaze.

Leveraging a network of enthusiastic people to share their telescopes also has a great potential for public engagement. Experienced astronomy live-streamers could support the growth of such a network with:

- a forum to answer questions;
- a calendar of events, to make the most of opportunities (such as conjunctions, space-era anniversaries, or a Messier-object marathon);
- a set of best practices, e.g. avoiding full Moon nights (unless the Moon itself is the focus), managing audience expectations and setting clear outcomes for the event.

Join us!

The discussion held at EPSC2022 in Granada and the follow-up Zoom session highlighted the need for an online platform to strengthen the network, share materials and host conversations to support the live-streaming of astronomy events worldwide. A sustainable home for this collaboration has been identified with Astronomy Without Borders (AWB), which has built infrastructure to manage active outreach through a worldwide network of formal and informal educators. In March 2023, the Astronomy Live-Streaming community was set up on the AWB platform. It is slowly growing, with an official launch in April on the occasion of the Global Astronomy Month. The first step to join is to go to astronomerswithoutborders.org and click "Become a Member", where you can add yourself to the "Astronomy Live-Streaming" community. You are also welcome to email us with any questions: claudia.mignone@inaf.it, graham@timeanddate.com, or helen.usher@open.ac.uk.

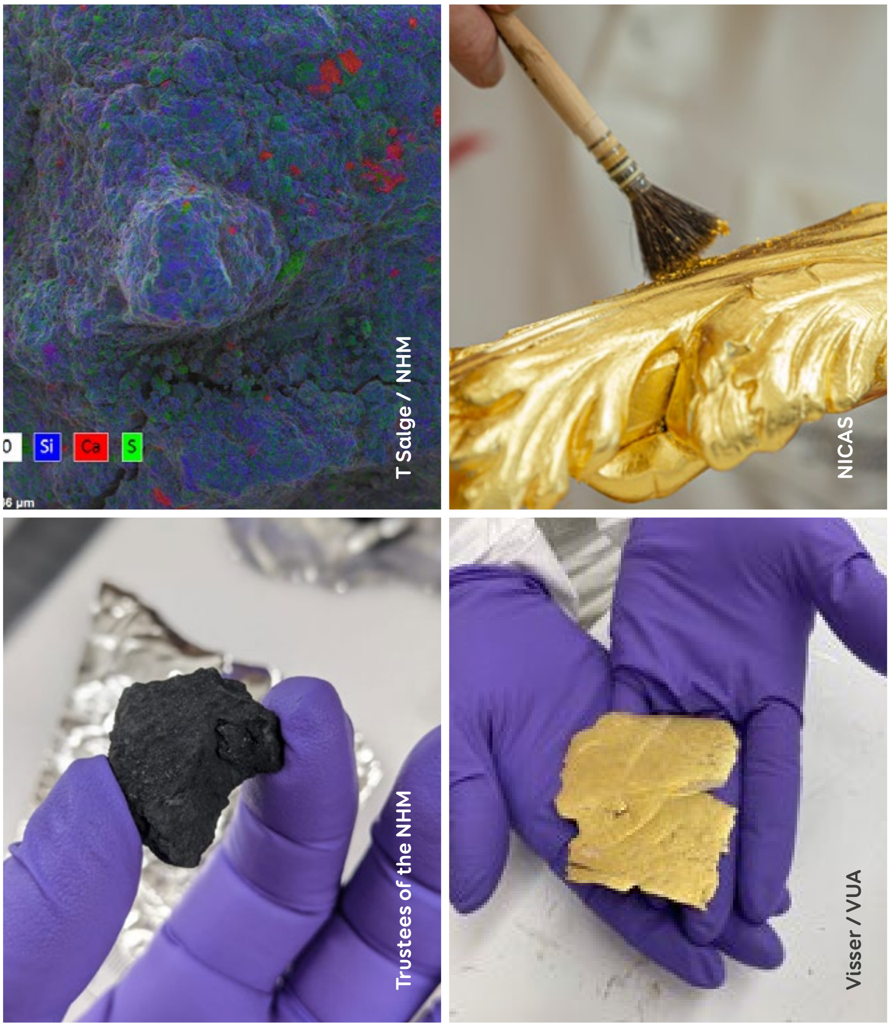
Find out more: 'Don't panic: A Guide to Live Streaming Events', Jones and Buckle, EAS 2023: https://bit.ly/Live-streaming-astronomy

Developing Labs for Research that is Out of this World

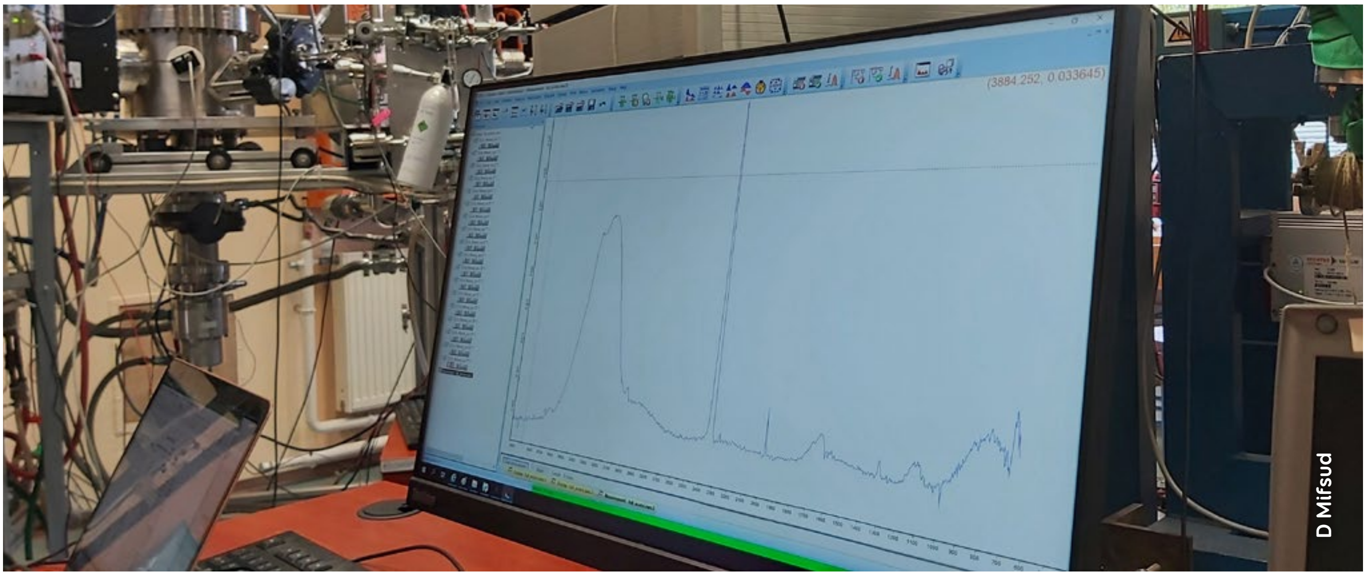
Gareth Davies (Vrije Universiteit Amsterdam, Netherlands) describes how investment from the European Commission has supported Europlanet's development of state-of-the-art facilities for planetary science - and other fields of research, such as cultural heritage.

Over the coming decade, European Space Agency (ESA) missions should yield ambitious rewards for the planetary science community. BepiColombo will finally reach Mercury, and JUICE will extend our knowledge of potential habitable worlds as it explores Jupiter's icy moons. The James Webb Space Telescope, CHEOPS, PLATO and ARIEL will take our understanding of exoplanets to a new level and start to show how our Solar System fits into the wider population of planets. NASA's Perseverance rover is collecting and caching samples that will be returned to Earth from Mars, and the international Artemis programme will kickstart a new era of exploration of the Moon.

Space missions are – by design – game-changers that provide data to enhance our understanding of planetary bodies and systems. However, these missions need to be part of a wider ecosystem of infrastructure to support the research community. In particular, the interpretation of data and the development of instrumentation for future missions both require access to a comprehensive suite of Earth-based simulation and analysis



Europlanet investment in upgrades to research facilities support a wide variety of research projects, from the analysis of meteorites (left, top and bottom) to gold leaf on cultural heritage objects (right, top and bottom).



An infrared spectrum of a deposited astrophysical ice spectrum, with the AQUILA chamber at Atomki, Debrecen, in the background.

facilities. It is here that Europlanet has an important role to play.

The European Commission (EC) aims to maximise the scientific output of research infrastructure across Europe through programmes whereby researchers from one country can visit and use facilities from another. Since 2009, Europlanet has implemented a series of EC-funded programmes for coordinated Transnational Access (TA) to planetary-related facilities. The current Europlanet 2024 Research Infrastructure (RI) project now supports access to over 40 simulation and analysis laboratories and analogue field sites in Europe and around the world.

Europlanet has also made strategic investments to improve the capabilities of facilities offered through the TA programme, with the goal of allowing researchers to fully exploit observations made in past, current and planned missions. Developments funded through Joint Research Activities (JRA) within successive EC-funded projects have been designed to better-simulate and understand diverse and extreme planetary environments. The upgrades have been focused on three main themes:

I. Generating spectroscopic data under realistic planetary conditions.

II. Physical and chemical characterisation of dust and ice-rich planetary environments.

III. Optimising the handling, characterisation and analysis of rare samples, particularly in the context of sample return missions.

All six major JRA projects funded by Europlanet have involved collaboration with industrial partners, either in the design and manufacture of equipment or directly as partners in optimising analytical instrumentation. Altogether, fifteen different research teams and two industrial partners from seven countries have contributed to the upgrades, with a total investment of over 1.5 million Euros.

In July 2023, all currently planned JRA projects are complete, with most of the enhanced facilities already in use by the community through the Europlanet TA programme.

Here we summarise the upgrade projects within the three themes.

Theme I: Tricks of the Light

Spectroscopic measurements of the surfaces of planetary bodies can reveal a wealth of information about the current and past conditions in the Solar System. However, the way in which radiation is absorbed and reflected is affected not only by the composition of rocks and their constituent minerals but also their shape, size and ambient conditions. Differences in mineralogy, grain type and compactness can all impact the way that light interacts with the target material. Understanding how the physical environment influences spectra is, therefore, vital at both the planning stage and in the detailed investigation phase of a mission.

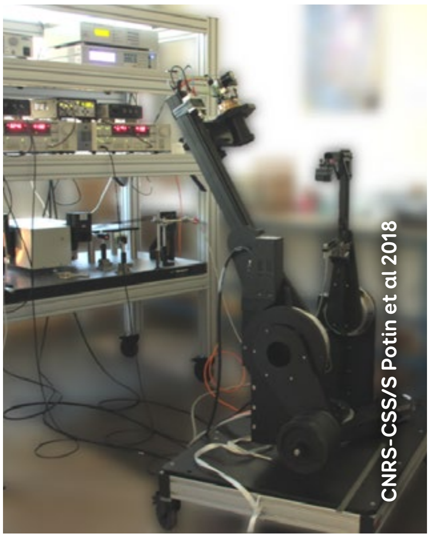
Europlanet has made JRA investments to develop two facilities that generate spectral measurements at low pressures and extreme temperatures. The upgrades will, ultimately, contribute to establishing the database required to allow unambiguous identification of the mineralogy and physical nature of the surfaces of many planetary bodies.

Project 1: From SHINE to SHADOWS

Upgrades to the Centre National de la Recherche Scientifique (CNRS) Grenoble's Cold Surfaces Spectroscopy facility

Team: Bernard Schmitt, Pierre Beck, Sandra Potin, Olivier Brissaud. **International Collaborators:** DLR

Interpretation of spectral observations of asteroids or comets present multiple challenges. The surfaces of many Solar System objects are extremely dark – primitive asteroids or comet nuclei may reflect less than 1% of the incoming visible



The SHADOWS Spectro-Gonio Radiometer at CSS Grenoble. Right: The glove-box of the cryo-chamber system at DLR.

light. Analysis of samples from space, such as rare meteorites, asteroid grains or interplanetary dust particles, may need to be carried out with only a few cubic millimetres of material. Laboratory investigations of the properties of analogue materials must also be carried out at very low temperatures and pressures if they are to provide a realistic comparison.

Through CNRS and Europlanet JRA funding, a multi-national group has supported the development of the CNRS Grenoble's Cold Surfaces Spectroscopy (CSS) facilities to provide comprehensive spectral data of rare and microscopic samples of minerals and ices. The facility houses two, custom-made spectro-gonio radiometers – instruments that analyse the light-scattering properties of planetary surface across a wide range of illumination and observation angles. The instruments are located in a dark, cold room that can be cooled down to -20°C and may also be used with cryogenic environmental cells that can cool samples down to -213°C under controlled atmospheric or vacuum conditions.

The facility's original instrument, SHINE (SpectropHotometer with variable INcidence and Emergence), dates back to the early 2000s. Europlanet and CNRS funding has enabled the development of SHADOWS (Spectrophotometer with cHanging Angles for the Detection Of Weak Signals), a next-generation spectro-gonio radiometer, completed in 2018.

SHADOWS has a radical new design that allows far greater sensitivity and the capability to measure the bidirectional spectral reflectance in the wavelength range of 0.4-4 micrometres (visible to near-infrared) of millimetre-sized dark samples at low temperatures. SHADOWS maintains the <1% absolute photometric accuracy (how accurately the instrument measures the absorbance of a sample) and wide geometrical range of SHINE, while decreasing the minimum sample size of the sample by three orders of magnitude and the minimum measurable reflectance by almost a factor of 100. Currently, SHADOWS is the only spectro-gonio radiometer worldwide able to measure samples with such small size and low albedo (down to below 0.1%).

Through Europlanet funding, two sample vacuum chambers (< 10^{-6} mbar) have been developed: the first allows measurements at small-to-moderate phase angles (between incoming and reflected light) of up to 60° under vacuum at cryogenic temperatures (down to -198°C). The second (phase angles <80°) can adjust the vacuum to one atmosphere from room temperature to 250°C with sample sizes up to 680 mm^3. Recent studies with the instrument include spectral investigations under vacuum conditions of an extensive series of dark meteorites of various classes, with the aim of matching them to their parent asteroids.

SHADOWS has also supported the research of several early career researchers, with much of the development and calibration work carried out by Sandra Potin as her PhD project

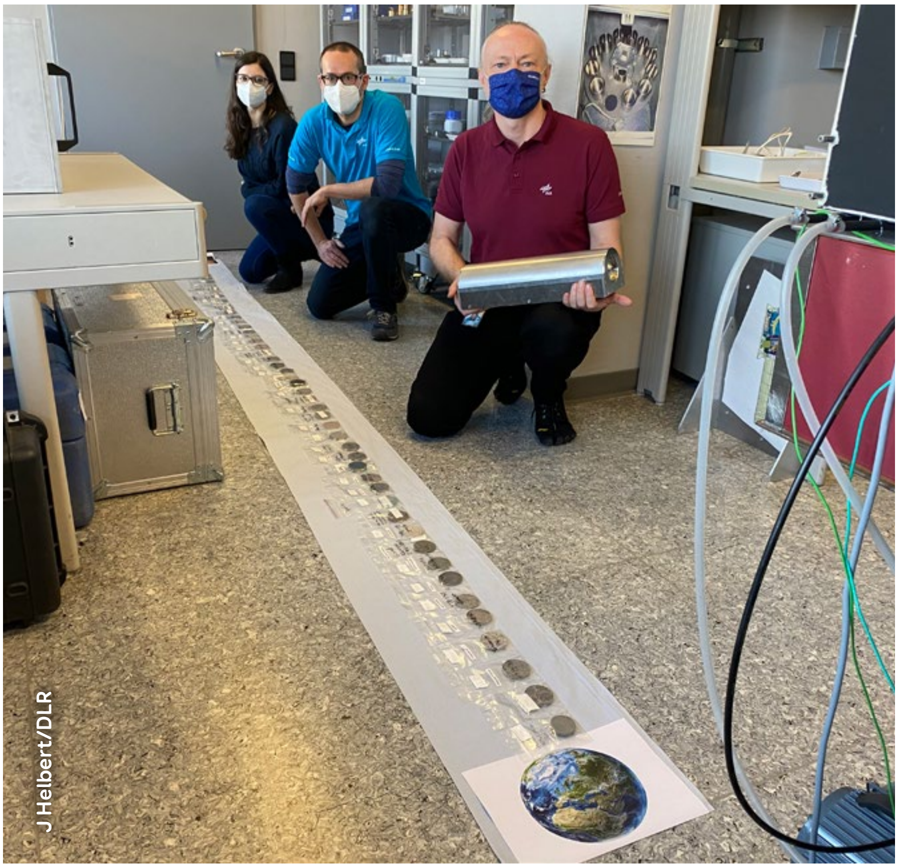
Project 2: Hot and Cold

Upgrades to DLR's Planetary Spectroscopy Laboratory (Germany)

Team: Jörn Helbert, Alessandro Maturilli (DLR). International Collaborators: CNRS

The Planetary Spectroscopy Laboratory (PSL) at DLR has used Europlanet JRA funding to extend spectral measurements at very high and very low temperatures. In 2018, capabilities were extended for measurements at high temperature, offering the community access to spectra obtained in emission at typical temperatures for the surface of Venus (460°C) and covering the infrared spectral range from 0.7 to 1.2 micrometres (and beyond).

This key development, which is globally unique, enables comparison



Giulia Alemanno, Alessandro Maturilli and Jörn Helbert with analogue samples for the PSL Venus Chamber at DLR in Berlin.

of laboratory spectra with mission data gathered in the spectral windows near 1 micrometre, where the venusian CO_2-rich atmosphere is transparent and where important information on the redox state and transition metal contents on the surface can be acquired (see 'Finding New Ways of Envisioning Venus', Europlanet Magazine Issue 2).

More recently, the expertise used to develop the vacuum chambers at the CSS facilities in Grenoble has been drawn on to construct a new cryo-chamber at DLR. The DLR chamber, completed in 2023, will enable spectral and gas analysis of icy samples under low-pressure atmospheres comparable to outer Solar System bodies (3 x 10^{-6} mbar). The vacuum system is automated and the minimum operational temperature is -140°C. A pair of synthetic diamond windows have been installed in the spectrometer and the external source to increase the range of wavelengths that can be measured. The addition of a gas analyser also enables the monitoring of gases released by the sample during the whole process of cooling and measuring.

Theme II: Worlds of Ice and Dust

Missions like Cassini-Huygens and Juno have revealed the highly complex nature of the relationships between gas giants, their intense radiation environments and their icy moons (see feature, page 18). To prepare for the arrival of JUICE and Europa Clipper, the scientific mission teams will need to understand how the high energy radiation emitted by Jupiter, as well as solar radiation, can change the chemical and physical conditions of ices on Europa, Ganymede and Callisto. Ongoing processing of ices, as well as the implantation of elements, can influence their physical properties, such as strength or melting conditions. As a result, laboratory-based studies of analogue ices are essential for accurately interpreting mission data and will, ultimately, help determine the habitability and astrobiological potential of icy moons.

If understanding ice is critical to studies of the outer Solar System, dust is the key to the inner Solar System. Dust has a major influence on spectroscopic measurements and provides a variety of hazards for human (and robotic) explorers, from toxicity to dust devils. Thus, laboratory-based simulations to unravel the characteristics, behaviour and movement of lunar and martian dust will be fundamental to future exploration programmes.

Project 3: Irradiated Ices

Upgrades to the Atomki facilities in Debrecen

Team: Béla Sulik, Zoltán Juhász, Péter Herczku, Sándor Kovács, Duncan Mifsud and Zuzana Kaňuchová.
International Collaborators: Atomki, the University of Kent, the Queen Mary University of London, Queens University of Belfast and Aarhus University

Through Europlanet's JRA programme, an international collaboration has developed a new European hub for studies of astrochemistry and astrophysics at Atomki's facilities in Debrecen, Hungary. The facility's capabilities have been expanded for studies of ion impact-induced physical and chemical processes in astrophysical ice analogues in the temperature range down to -253°C. To complete this ambitious project, Europlanet EC-funding has been complemented by grants from the Eötvös Loránd Research Network (ELKH), Hungarian national funding agencies and the Royal Society in the UK.

In 2020, an ultra-high vacuum (UHV) chamber – the Ice Chamber for Astrophysics / Astrochemistry (ICA) – was installed at the beamline of the 2MV Tandetron accelerator. The facility models conditions in the higher energy part of the solar wind and the low energy part of galactic

Sándor Kovács working on preparing an astrophysical ice analogue at the AQUILA facility at Atomki.

cosmic rays (operating with ion beams from protons to iodine and with various charge states in the 200 keV-20 MeV ion energy region). An early career researcher, Duncan Misfud, supported the training programme and was the first author on the paper describing the facility.

Since installation, the apparatus has been augmented with a secondary charged-particle impact source, systems for monitoring the delivery of the ion-beam to the sample surface, and development of the range of target deposition methods. The first TA visit using the ICA facility took place in November 2020/February 2021 and more than 10 experimental TA programs have been completed. Results have been presented at EPSC2021, EPSC2022 and other conferences, and 8 journal papers have already been published.

A second UHV chamber, provided by Queens University Belfast, was installed on the beamline of the Electron Cyclotron Resonance Ion Source (ECRIS) in 2022. The Atomki-Queens University Ice chamber for Laboratory Astrochemistry (AQUILA) is designed to mimic processes on the surfaces of icy moons induced by the solar wind or magnetospheric ion impacts. The new installation represents a significant expansion of capabilities to monitor structural and chemical changes to ices during vacuum ultraviolet (VUV) irradiation by conducting simultaneous spectroscopic and quadrupole mass spectrometry analysis. Different gas molecules can be deposited on the substrate at minimum temperatures of around -260°C and solid materials can also be evaporated onto the substrate by an effusion cell.

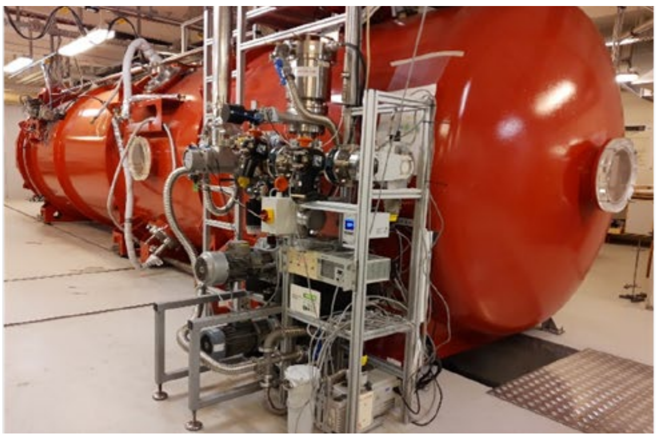
The first TA project has already been completed and, when the AQUILA facility was offered in Europlanet's TA Call 3, it was so popular that it was oversubscribed.

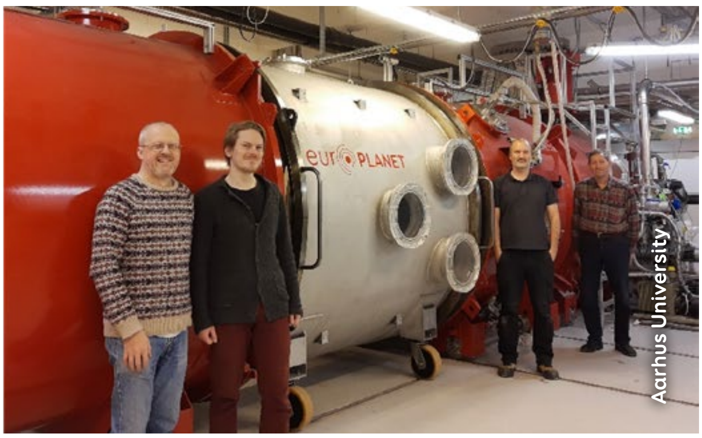
Project 4: Winds of Change

Upgrades to Aarhus University's Planetary Environment Facility (Denmark)

Team: Jonathan Merrison. International Collaborators: Lulea Technical University

The Planetary Environment Facility (PEF) is the most advanced Mars





Left: New pumping system for improved vacuum and evacuation rates at the PEF, Aarhus. Right: a new chamber section specifically designed and constructed for Europlanet TA activities with team members Jon Merrison, Jeppe Kjer, Jens Jacob Iversen and Keld Rasmussen.

surface simulator in the world, utilised by ESA and NASA as well as research and industrial communities linked to planetary science.

JRA funding through Europlanet 2024 RI has supported upgrades to the PEF to enable the simulation of icy and airless environments including icy moons and the lunar environment. The new components include additional pumping systems for enhanced vacuum capabilities, and a new test section dedicated to icy-body studies. The 100-fold improvement in vacuum capabilities not only enables new types of experiments but also enhances atmospheric gas purity and faster turnover for experiments at the facility.

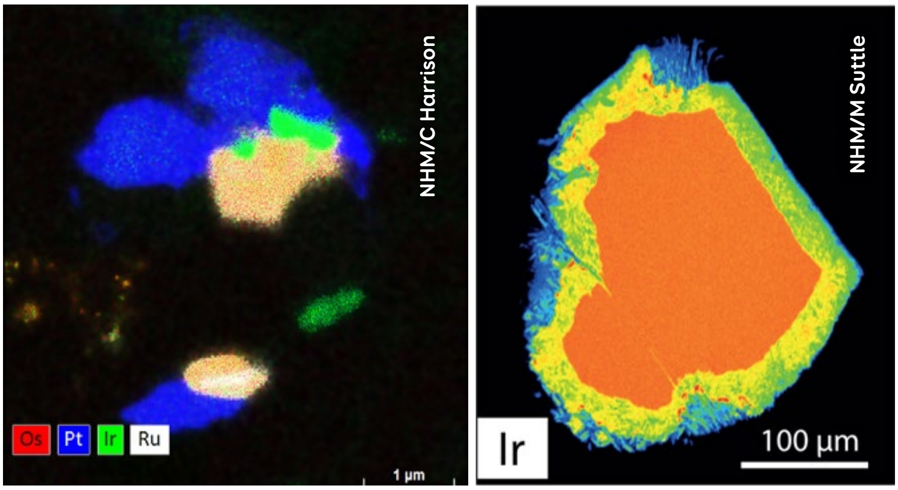
Over the past decade, Europlanet funding has significantly upgraded capabilities at the PEF for martian environmental simulations, specifically for wind-driven ice and sand transport, as well as sensor development. The addition in 2018 of a Particle Image Velocimetry (PIV) system, comprising a high-speed camera and laser sheet system, has enabled the tracking of individual suspended particles and the quantification of their velocity and the processes through which they are transported. The system's installation has enabled various interesting phenomena to be studied in the facility for the first time, including dust aggregates being entrained (lifted), transported and broken up to generate dust.

A new air cooling system means that it is now possible to measure air temperature under low pressure conditions (~10 mbar), with a minimum (average) chamber air temperature of less than -50°C, while applying wind. An LED-based solar simulator, operating at far-ultraviolet wavelengths, has also been installed enabling irradiation studies at low pressure (10 mbar) over several hours.

Multiple members of the community have already used the upgraded facilities in TA visits. Investigations have included studies of ash from large-scale volcanic eruptions on Earth, ice ripples on icy planetary surfaces, and water ice jets emanating from icy moons.

Theme III: Do no harm

Meteorites and samples returned by missions are key to understanding the formation and evolution of the Solar System. The sophistication and number of techniques available in terrestrial laboratories vastly outstrip what is possible in-situ. Planetary missions to date have collected material from the Moon, asteroids, comets, interstellar dust and the solar wind. The increasing focus on sample return by international agencies should mean that there will be a bounty of new material from the Moon, Mars and Phobos delivered back to Earth for analysis over the next decade or so. However, many standard laboratory techniques require that part of the sample is destroyed during the analysis. Where samples may consist of single grains (e.g. particles of the solar wind returned by the Genesis mission), destructive analysis techniques are ruled out by the fact that there is insufficient material to sacrifice. To make the most of upcoming sample return missions, new techniques need to be developed urgently. Two Europlanet JRA investments have concentrated on improving characterisation of space samples in a minimally destructive manner, ensuring that precious samples can be preserved for use by future generations.



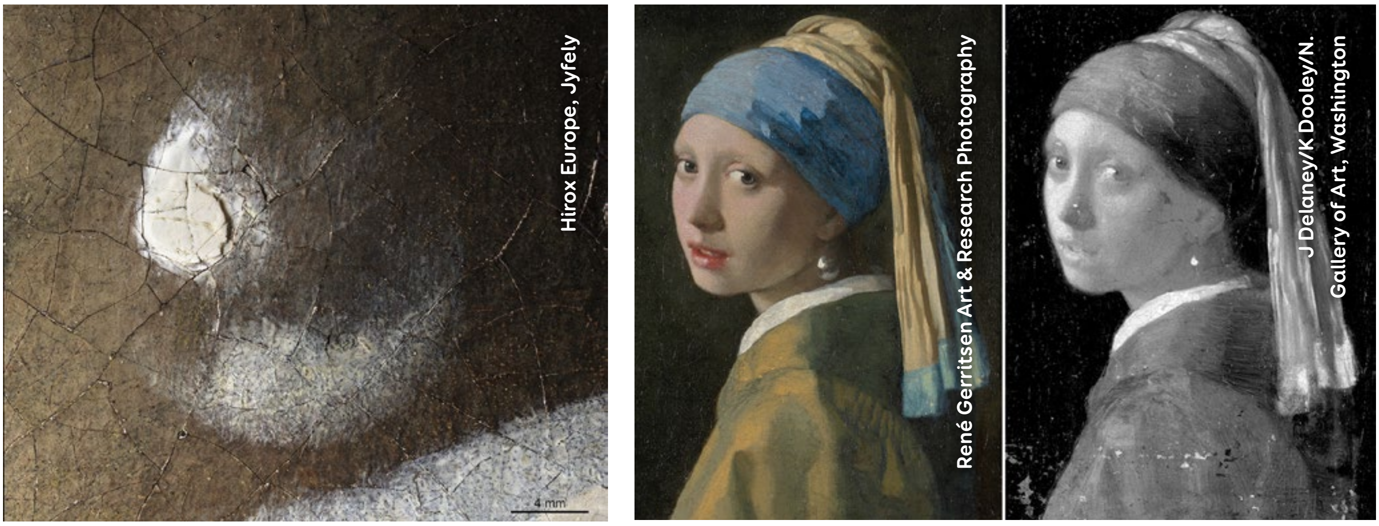
Left: Image of a complex grain from Dar Al Gani 431, an anomalous CK3 chondrite meteorite using new isotopic analysis techniques developed at the NHM. Right: Iridium map produced on a PGE nugget in the Winchcombe Meteorite.

Project 5: Procedures for Preservation

Updates to Natural History Museum (NHM)

Team: Rhiannon Heard, Sara Russell, Tobias Salge (NHM) and Penelope Wozniakiewicz (University of Kent).
International Collaborators: DLR, VUA, Brucker Nano GMBh

The aim of this project has been to characterise minerals within meteorites with minimal or no sample preparation. The idea came about through a collaboration between Tanja Mohr-Westheide of the Museum für Naturkunde Berlin and Tobias Salge of NHM initiated during a TA visit to London in 2019. The techniques were trialled on terrestrial Platinum Group element Nuggets (PGN) under conditions suitable for the analysis for small (<1mm) extra-terrestrial grains. PGN are chemically resilient objects, with very high vaporisation temperatures, that are found as micrometre-sized alloys in chondritic meteorites and in materials that have been modified though impacts. While PGN



The origin of the lead in white paint highlights in Vermeer's Girl with the Pearl Earring was identified, as part of the Mauritshuis 'Girl in the Spotlight' research project, with technology upgraded through Europlanet investment.

are thought to have condensed very early in Solar System history – or even be pre-solar – their composition is not well understood. To date, they have been too small to analyse by most techniques and, while their chemistry can be investigated using electron dispersive X-rays (EDX), overlaps in the X-ray energies of relevant elements make quantification challenging.

The new quantification procedures developed in the Europlanet JRA are based on a combination of techniques, including scanning electron microscopy (SEM) and energy-dispersive spectrometry (EDS) microanalysis using Brucker's QUANTAX FlatQUAD detector. Studies with the new protocols have already produced valuable science, demonstrating that the composition of terrestrial PGN is very complex and likely related to formation and modification under different volatile and oxidation conditions.

Follow-up work has developed an analytical protocol for SEM-EDS quantification of unpolished samples. Surface roughness and topography leads to inconsistencies in the numbers of X-rays hitting the detector, making quantification challenging. This work is potentially of high importance for the analysis of planetary materials, as it would enable the characterisation of precious sample return material without any destructive preparation at all. Using a variety of mineral species relevant to extraterrestrial samples (e.g. apatite, olivine, calcite, silicon carbide and glass) a method has been successfully developed for quantification, albeit with higher errors than is possible for polished samples.

The development work for this JRA project was undertaken by Rhiannon Heard, a postdoc at the NHM. A publication (Heard et al.) is in preparation and will be submitted shortly. Future plans include sharing the new capabilities with the PSL team at DLR, who are currently installing the same Bruker detector. The work on the JRA project is complete and now included in Europlanet's TA programme.

Project 6: State-of-the-Art Applications

Upgrades to VUA-CNRS-ThermoFisher

Team: Janne Koornneef, Paolo d'Imporzano, Matteo Branchetti and Gareth Davies, Vrije Universiteit Amsterdam (VUA).

International Collaborators: Laurie Reisberg Centre de Recherches Pétrographiques et Géochimiques Nancy, ThermoFisher.

In this academic-industrial JRA collaboration with the instrument manufacturer ThermoFisher, minimally-destructive methods for isotopic analysis have been optimised for very small sample amounts. New collector technology has reduced the amount of material required for analysis by a factor of ten. Despite potential problems with contamination from sample handling in the laboratory, Europlanet-funded work has successfully developed clean methods for the processing and analysis of picogram amounts of isotope systems.

As well as being used to investigate rare extraterrestrial samples, the technology has been applied in the cultural heritage field to study the origins of unique artefacts. Analysis of the white paint on the pearl earring from Vermeer's famous portrait has revealed that the lead in the paint and primer came from a mine in the UK's Peak District. The VUA team also recently worked with the national cultural heritage agency and the Naturalis Biodiversity Center to establish the provenance of gold used to gild the Dutch State Golden Coach in 1898. Isotopic analysis of the approximately 1 micrometre-thick layer of gold foil confirmed oral history reports that the gold came from eastern Suriname.

bit.ly/epn2024ri-ta2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Life Beyond Us:
Showcasing Astrobiology through Science Fiction Stories

Julie Nováková (European Astrobiology Institute, Czech Republic), co-editor of the *'Life Beyond Us'* anthology, describes this new collection of 27 science fiction stories by award-winning authors and 27 essays by scientists.

Ever since the days of Shelley, Verne or Wells, science fiction has been inspired by science and inspired scientists in turn. Its power of imagination, use of narrative, and popularity make the genre well-suited for raising interest in science. The new anthology, *Life Beyond Us*, aims to achieve this goal with a novel approach of mixing original science fiction stories about astrobiology, written by world-renowned authors, with accessible essays by scientists addressing topics from each story.

The story-essay combination blends entertainment and scientific knowledge to arouse curiosity, carrying the reader to the boundary between science and science fiction. Effective science communication and critical thinking are more than essential nowadays, and *Life Beyond Us* seeks to foster them and entertain at the same time. An online guide is also being prepared for educators wishing to use *Life Beyond Us* in class, with materials for teachers freely available on the European Astrobiology Institute (EAI) website.

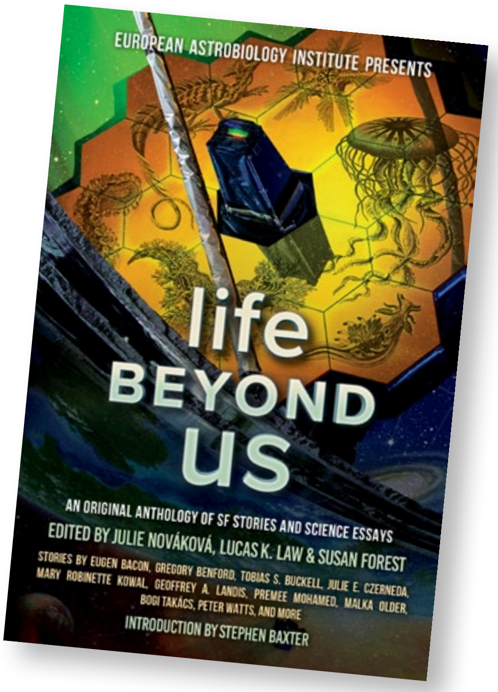
As a science fiction author and evolutionary biologist, with the

Julie Nováková with a copy of *Life Beyond Us* at ComicCon Prague in April 2023.

responsibility of co-leading the outreach working group of the EAI, it has been my pleasure to co-edit *Life Beyond Us* alongside Lucas K. Law and Susan Forest, who produced critically acclaimed anthologies such as *Where The Stars Rise* and *The Sum of Us*. Its contributors include award-winning authors, and the science essays are by experts from national space agencies, universities and scientific institutions across the globe. Topics range from planetary protection to robotic space exploration, exomoons, space agriculture or water world habitability, all the way to xenolinguistics (possible alien languages) or the Search for Extraterrestrial Intelligence (SETI).

EAI was founded in 2019 to support research, education and outreach in astrobiology across Europe and beyond. With NASA's Perseverance on Mars, private science missions planned to launch toward Venus and elsewhere, closer exploration of the icy moons on the horizon, and exciting exoplanet discoveries practically on a daily basis, astrobiology is a booming scientific field bound to create general interest. Science fiction is a perfect tool to bring astrobiology closer to the public and let people feel the curiosity and joy of discovery at the core of science and science fiction. *Life Beyond Us* is the second astrobiological science fiction anthology by EAI, following *Strangest of All*, a "proof-of-concept" e-book anthology of reprint science fiction stories and original essays. With thousands of downloads, positive reception and use as a science teaching material, the book showed the merit of such an outreach approach. To publish *Life Beyond Us*, EAI teamed up with Laksa Media, an award-winning Canadian publisher with a unique model of helping a cause via each book it publishes – in this case, science education.

Life Beyond Us is published in paperback, hardcover and ebook formats, and is available at all major online retailers as well as selected brick-and-mortar bookstores. The anthology has already been presented at EAI's Biennial European Astrobiology Conference (BEACON),



ComicCon Prague, MetropolCon Berlin and will be showcased at other in-person, hybrid and online events over coming months.

Links:

https://bit.ly/LifeBeyondUsAnthology

europeanastrobiology.eu

laksamedia.com

Outreach and Education

Icy Moons Collection of Educational Resources

To celebrate the launch of ESA's JUICE mission, Europlanet has released a new collection of free educational resources themed around icy moons in our Solar System. The first three resources, on Europa, Ganymede and Enceladus, are now available for educators and science communicators to try out. The educational packs include presentations, teachers' notes, videos, links to additional information and a glossary of terms related to the exploration of these mysterious worlds. The resources are also linked to seven laboratories that simulate conditions relevant to icy moons and are accessible through Europlanet's Transnational Access programme. The resources are targeted at students aged 10-14 years old and cover topics common on European educational curricula for biology (conditions for life, life in extremes), physics (magnetism), chemistry (states of matter, solutions), and geology (surface landforms, hydrothermal vent systems). New resources and translations will be added over the coming months.

https://bit.ly/EuroplanetIcyMoonsCollection

Europlanet's new Icy Moons Collection of educational resources includes teachers packs (top left) and video experiments (top right).

CommKit

Thibaut Roger (Europlanet Communications Team/Universität Bern) explores the use of games and play-related formats for research and science communication.

The use of games and play can be a powerful resource to harness for science and outreach. As an example, 'Project Discovery' enlisted 77,709 players of the video game EVE Online in a citizen science project to analyse potential exoplanet transits. In just six months, the Project Discovery players classified a staggering 44.4 million transits in a set of 176,802 light curves from the satellite CoRoT. As well as contributing to an achievement that would have taken the CoRoT science team years to complete, players benefited through in-game rewards.

Board games can also be used to communicate science in an interactive environment that favours two-way exchanges. With games designed primarily to entertain, and educate as a result, players can have fun without even realising that they are learning. The use of board games in education can have many benefits, particularly for younger children. Along with increasing social interactions and developing critical thinking, players can expand 'soft skills' such as negotiation, communication or problem solving. The educational value of board games may not rely so much on the material content of the game (cards, etc.) but in the mechanisms of the game itself, which offer parallels to the scientific process. Educational impact can also be greatly enhanced through appealing artworks or a strong sense of enjoyment derived from playing.

The board game 'ET - A Solar System Adventure'.

Collaborative board games, rather than competitive ones, can work particularly well for education. This is good news, as collaborative games are on the increase, winning several high profile prizes in the last few years. With a general resurgence in popularity of board games in recent years across all age groups, there's never been a better time to try using games during your events. If you don't feel ready to create your own game, there are many existing games that relate to planetary science. Here are some you could try:

- **ET - A Solar System Adventure** Developed by the Instituto de Astrofísica e Ciências do Espaço, with support from the Europlanet Public Engagement Funding Scheme, this board game explores the different planets of the Solar System and their habitats. The game is available in Portuguese and English. https://bit.ly/ETAdventureGame
- The University of Liège has created games in French and English and on various themes, including astrobiology, building a space mission, and the objects observed by the Athena satellite. https://bit.ly/ULiegeJeux
- **Explore Mars! A Rover Game** Available in English and Spanish, this game from Arizona State University puts the players in the shoes of the Mission Control of a martian rover. https://bit.ly/ExploreMarsGame

Find out more about gaming and science communication:

- Article about the history of educational board games: https://bit.ly/BoardGamesSciCom
- Ten simple rules for designing analogue science games: https://bit.ly/10RulesScienceGames
- Project Discovery: https://bit.ly/ProjectDiscoveryEVE

Planetarily yours,

Thibaut

If you have science communication tips and tricks to share, please reach out to our Communications Team at media@europlanet-society.org

Steps to Collaboration

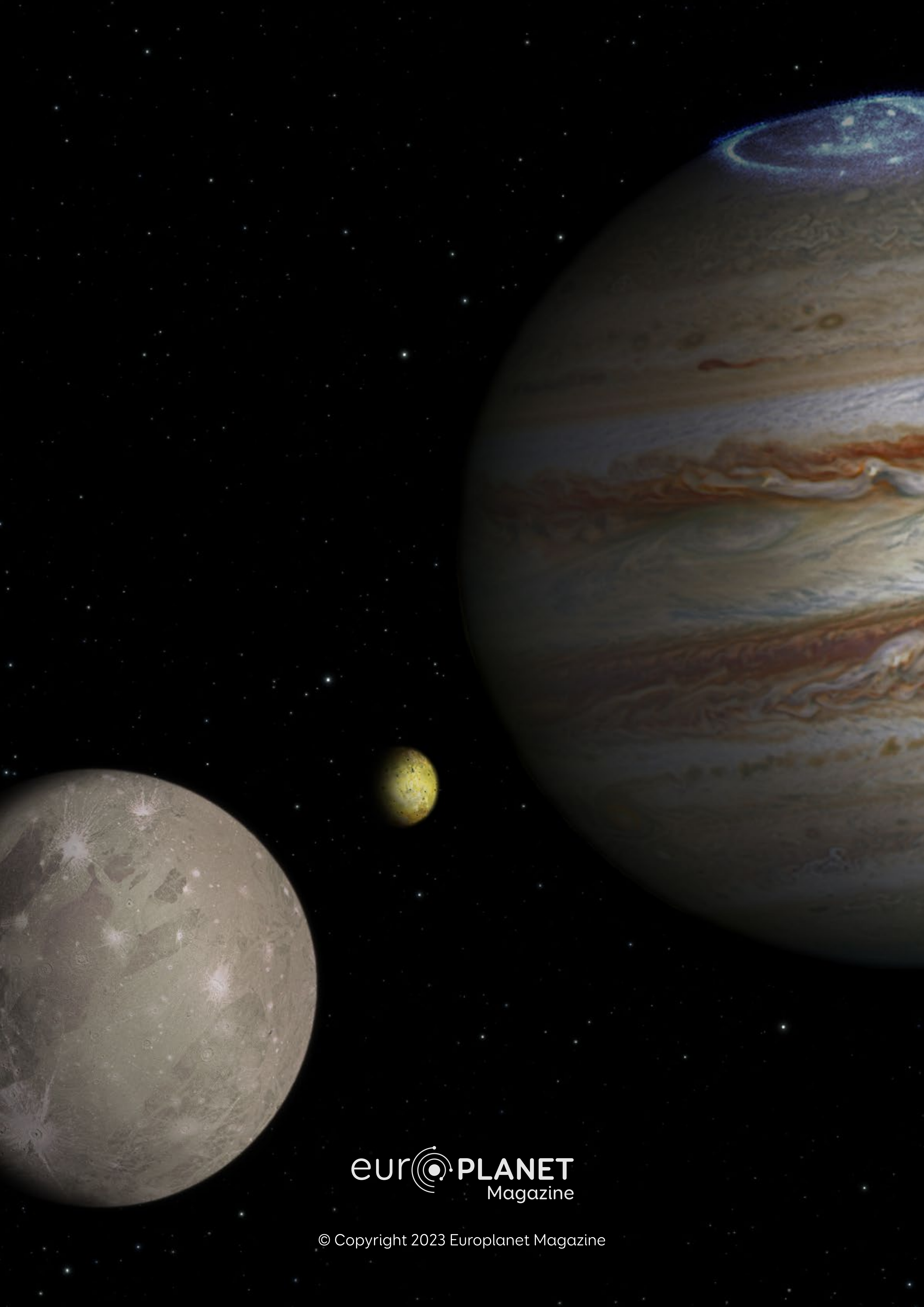
Nigel Mason, President, Europlanet Society reflects on efforts to build a more collaborative European space science community

The space research networks workshop at ERIM 2023.

The recent Europlanet Research Infrastructure Meeting (ERIM) in Bratislava (In Focus, page 4) included a workshop that brought together Research infrastructures (RIs) and networks whose focus is on space research – from cosmology and the birth of the Universe to astrobiology and the origins of life. Europe is one of the leading international centres in this field, with strong academic and industrial communities. However, European research is, by necessity, multinational, which can bring challenges in cross-border collaboration and effective integration. The European Space Agency (ESA) comprises 22 full member states and cooperates with additional European Union (EU) members, as well as international partners. Most EU-funded projects are also international co-operations, involving both EU member states and, increasingly, partners around the world. The Europlanet 2024 Research Infrastructure (RI) project currently has partners in 23 countries across 5 continents. The Europlanet Society is open to members in every European country and beyond.

As well as being multinational, space science is also inherently multidisciplinary; a wide range of fields are required to further the exploration and – increasingly – the exploitation of space (Planetary Perspectives on asteroid mining, page 13). The Europlanet Science Congress now attracts contributions from aeronomy, astrobiology, astrochemistry, astrophysics, cosmochemistry, geosciences, heliophysics and meteoritics. Europlanet, therefore, increasingly overlaps and collaborates with other research communities. Networks and RIs in related fields include the highly successful Radionet (radio astronomy) and Opticon (optical-infrared astronomy) RIs, the recently established ChETEC-Infra RI (dedicated to nuclear astrophysics) and ESCAPE (the European Science Cluster of Astronomy and Particle physics ESFRI research infrastructure). Europlanet is also engaged with strategic networks such as ASTRONET and ESFRI (the European Strategy Forum on RIs), which provide wider overviews of space research and suggest future strategic directions.

The ERIM workshop was a timely review, given the context of strategic plans for ESA, the EC (through the Horizon Europe programme), ESFRI and ASTRONET (page 7) that are currently being developed and published and will shape the future of European space research over the next decades. Participants in the workshop agreed that a more cohesive and powerful voice for the space research community to key stakeholders is now needed. An important step to achieve this will be the creation of a 'Network of Networks' that brings together the different space and astronomy organisations to discuss areas of mutual interest, collaborate in joint activities, and make collective approaches to major funders and stakeholders. Discussions on the establishment of this 'Network of Networks' are progressing and the first meetings are planned for September 2023. This is a welcome milestone in the development of a sustainable space science community for Europe.



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