INTERNATIONAL
ASTRONAUTICAL
FEDERATION

IAF HIGHLIGHTS 2025

Connecting @ll Space People
for a sustainable future

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Abbreviations

3G+	Geography, Generation, Gender, +
AEB	Brazilian Space Agency
AI	Artificial Intelligence
AIAA	American Institute of Aeronautics and Astronautics
ALCE	Latin American and Caribbean Space Agency
API	Application Programming Interface
ASI	Italian Space Agency
CLIODN	Committee for Liaison with International Organisations and Developing Nations
CNSA	China National Space Administration
COSO	Committee of Sponsoring Organizations
COPUOS	Committee on the Peaceful Uses of Outer Space
CSA	Canadian Space Agency
CNES	Centre National d'Etudes Spatiales
DART	Double Asteroid Redirection Test
DLR	German Aerospace Center
EO	Earth Observation
ESA	European Space Agency
ESOC	European Space Operations Centre
EVAs	Extravehicular Activities
FAA	Federal Aviation Administration
GNSS	Global Navigation Satellite System
GOSAT-GW	Global Observing SATellite for Greenhouse gases and Water cycle
GPS	Global Positioning System
GRC	Governance, Risk and Compliance
HSF	Human Spaceflight
HTV-X	New Space Station Resupply Vehicle (not abbreviation, but also known as)
IADC	Inter-Agency Space Debris Coordination Committee
IAF GNF	Global Networking Forum
IN-SPACe	Indian National Space Promotion and Authorization Centre
ISEP	IAF Space Economic Platform
ISO	International Standarization Organization
ISRO	Indian Space Research Organisation
ISS	International Space Station
ISU	International Space University
ITU	International Telecommunication Union
JAXA	Japan Aerospace Exploration Agency
JPL	Jet Propulsion Laboratory
JWST	James Webb Space Telescope
LCNS	Lunar Communication and Navigation Service
LCRD	Laser Communications Relay Demonstration
LEO	Low-Earth Orbit
LTS	Long-term Sustainability
LUPEX	Lunar Polar Exploration
MMoP	International Meeting for Ministers and Members of Parliaments
MMX	Martian Moons eXploration
MTG	Meteosat Third Generation
NASA	National Aeronautics and Space Administration
NEO	Near-Earth Object
NLP	Natural Language Processing
NOSA	Norwegian Space Agency
NSIL	NewSpace India Limited
OSAM	On-orbit Servicing, Assembly, and Manufacturing
PNT	Positioning, Navigation and Timing
PPP	Public-Private Partnerships
QKD	Quantum Key Distribution
R&D	Research and Development
SAR	Search and Rescue
SDGs	Sustainable Development Goals
SDR	Software Defined Radio
SLS	Space Launch System
SOCA	Space Operations Committees Alumni
SpS	Special Sessions
SRM	Solid Rocket Motor
SSA	Space Situational Awarness
STEM	Science, Technology, Engineering and Mathematics
SWOT	Surface Water and Ocean Topography
TC	Technical Committee
UN	United Nations
WG	Working Groups

Welcome Message

Gabriella Arrigo

President,
International Astronautical Federation (IAF)

Dear IAF Community,

It is my great honour to share with you the IAF 2025 Highlights. As I begin my tenure as President of the International Astronautical Federation (IAF), I am deeply inspired by the strength and diversity of our global community. This year has been marked by exceptional growth, with over 40 new members joining the Federation, bringing us to 604 organizations across 82 countries. This continued expansion reflects the trust placed in the IAF as a truly international platform for cooperation and dialogue.

A central highlight of 2025 was, of course, the International Astronautical Congress (IAC) - our flagship annual event, organized by the IAF since 1951. The IAC 2025 in Sydney, Australia, once again demonstrated the vibrancy, depth, and collaborative spirit that define our community, as thousands of experts, leaders, and enthusiasts came together to advance the frontiers of space and introduce emerging trends in space technologies that benefit our daily lives and continuous progress.

Beyond the IAC, the year brought a series of impactful and forward-looking gatherings. Our traditional IAF Spring Meetings, once again provided an essential platform for strategic reflection and decision-making, reinforcing the Federation's long-term vision and priorities. We were also pleased to convene the IAF Global Space Exploration Conference (GLEX 2025) in New Delhi, India, which advanced dialogue on the future of space exploration. The IAF International Space Forum at Ministerial Level (ISF 2025) in Manila, the Philippines, placed a particular focus on the Southeast Asia region, fostering substantive discussions between ministers, government representatives, academia, and leaders of the global space community. The discussions reaffirmed the importance of space as a strategic enabler of sustainable development, innovation, and international cooperation.

Looking ahead, the Federation is actively organizing two major upcoming events that will further advance our mission: the IAF Global Space Conference on Climate Change (GLOC 2026), to be held on 2-4 June 2026 in Kigali, Rwanda, where we will highlight the vital contribution of space-based solutions to addressing global climate challenges.

Later this year, from 5-9 October 2026 we will bring the global space community together in Antalya, Türkiye, for the 77th International Astronautical Congress (IAC 2026), under the theme "The World Needs More Space".

As tradition, this publication includes the 2025 IAF General Assembly review, the IAF Committees Briefs, and the IAF Logbook, reflecting the breadth of the Federation's activities and its sustained commitment to advancing space advocacy worldwide.

I warmly encourage you to relive this remarkable year through the articles and photos featured in this Highlights edition. Together, they capture not only our collective achievements, but also the spirit of collaboration and dedication that continue to propel the IAF forward.

IAF 2025

Events Overview

IAF General Assembly Report 2025

The International Astronautical Federation General Assembly has gathered during the International Astronautical Congress, IAC 2025 in Sydney, Australia, in two sessions (Monday, 29 September 2025, and Friday, 3 October 2025).

2025 Elections of IAF Officers

IAF President, Gabriella Arrigo, officially took on her new role leading the Federation and four new IAF Vice Presidents have been elected by the General Assembly:

Yusuf Kıraç, Chairman of the Board and President, Turkish Space Agency (TUA), has been appointed as IAF VP for **Relations with International Organizations**

Nikol Koleva, Executive Director, Space Generation Advisory Council (SGAC), has been appointed as IAF VP for **Diversity Initiatives**

Michael López-Alegría, Chief of the Astronaut Office and Ax-1 Mission Commander, Axiom Space LLC, has been appointed as IAF VP for **Astronauts Relations and Outreach**

Gaspard Twagirayezu, Chief Executive Officer (CEO), Rwanda Space Agency (RSA), has been appointed as IAF VP for **Emerging Space Ecosystems**

Selection of Host City for IAC 2028

The IAF General Assembly at its second session on 3 October 2025, selected Samarkand, Uzbekistan, as Host City for IAC 2028. The Hosting Organization is Uzcosmos, an IAF member since 2023.

IAF Finance

The IAF has also approved the **final accounts 2024 and Auditor's Statement 2024** and the **revised budget and preliminary accounts 2025** and the **Proposed Budget 2026.**

New IAF Members

The IAF General Assembly also approved the applications of 57 new Member Organizations. With this, the IAF Membership comprises 604 Member Organizations from 82 countries, bringing 1 new country in the Federation Members' community: Belarus.

The New IAF Members are:

Organization	Category	Region	Country
4iG Space and Defence Technologies	Space Industry	Europe	Hungary
Agencia Espacial Española	Space Agencies / Space Offices	Europe	Spain
Angkasa-X	Space Industry	Asia	Malaysia
ANYWAVES	Space Industry	Europe	France
ARRIBES	Space Industry	Europe	Spain
Astroengineering Technologies LLC	Space Industry	Europe	Belarus
AstroWorks Ventures LLC	Space Industry	North America	United States
Beijing Zerog Space Technology Co., LTD	Space Industry	Asia	China
BERLIN SPACE Consortium GmbH	Space Industry	Europe	Germany
Cangyu Space	Space Industry	Asia	China
Centro Interdisciplinario de Estudios Espaciales	Universities	Latin America & Caribbeans	Argentina
CHASM	Associations and Professional Societies	Europe	Switzerland
Codimaths	Space Industry	Asia	India
Department of Electronic Communications	Space Agencies / Space Offices	Europe	Cyprus
DHV Technology	Space Industry	Europe	Spain
ELITAL SPACE AND DEFENCE	Space Industry	Europe	Italy
EOIntelligence	Space Industry	North America	Canada
Epyphite Corp	Space Industry	Asia	Singapore
Fondation pour la Recherche Stratégique	Research and Development Organisation	Europe	France
Geospatial AI Sdn Bhd	Space Industry	Asia	Malaysia
Gilmour Space	Space Industry	Oceania	Australia
GTD	Space Industry	Europe	Spain
GTL Co., Ltd.	Space Industry	Asia	Republic of Korea
Harbin Institute of Technology	Universities	Asia	China
Harpy Aerospace	Space Industry	Asia	India
Involve	Space Industry	Europe	Italy
Korea AeroSpace Administration	Space Agencies / Space Offices	Asia	Republic of Korea
Laboratory for Space Research, The University of Hong Kong	Universities	Asia	Hong Kong - China
Lunar Policy Platform (LPP)	Space Industry	Europe	Estonia
MITRE Corporation	Research and Development Organisation	North America	United States

Organization	Category	Region	Country
MSP Philippines	Space Industry	Asia	Philippines
Nokia of America Corporation	Industry	North America	United States
Obuda University	Universities	Europe	Hungary
ocullospace	Space Industry	Asia	Singapore
Omspace Rocket and Exploration Pvt Ltd	Space Industry	Asia	India
OrbitArch	Space Industry	Asia	India
Prague Security Studies Institute	Associations and Professional Societies	Europe	Czech Republic
Praxis Aerospace	Space Industry	Oceania	Australia
PRETO BUSINESS Corp.	Space Industry	North America	United States
Quality Training Academy	Universities	Asia	Saudi Arabia
Rendezvous Robotics	Space Industry	North America	United States
Safe on Orbit	Space Industry	Latin America & Caribbeans	Brazil
Satcom Industry Association (SIA-India)	Associations and Professional Societies	Asia	India
Satlab	Space Industry	Europe	Denmark
Science Museum Group	Space Museums	Europe	United Kingdom
Shanghai Anzhe Technology Co., Ltd	Space Industry	Asia	China
Shenzhen University	Universities	Asia	China
Solar Space Technologies Pty Ltd	Space Industry	Oceania	Australia
Technical University of Munich	Universities	Europe	Germany
Turin Polytechnic University in Tashkent	Universities	Asia	Uzbekistan
Ubinexus	Space Industry	Asia	China
Universidad Nacional Tecnológica de Lima Sur	Universities	Latin America & Caribbeans	Peru
University of Canterbury	Universities	Oceania	New Zealand
Veganaut, Inc	Industry	North America	United States
Western Australian Space Science Education Centre	Space Museums	Oceania	Australia
Zenith Law Firm	Space Industry	Asia	China
Zhejiang E.O. Paton Welding Technology Research Institute	Research and Development Organisation	Asia	China


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IAF Symposium 2025

The IAF Symposium is a biennial event organized by the International Astronautical Federation (IAF) in conjunction with the Scientific and Technical Subcommittee (STSC) of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS).

The IAF Symposium brings together experts, policymakers, and representatives from space agencies, industry, and academia to foster knowledge exchange, strengthen global cooperation, and explore innovative solutions to current and emerging challenges in space sector. Through high-level discussions and expert presentations, the IAF Symposium reinforces the Federation's commitment to promoting international partnerships and advancing the peaceful uses of outer space.

The 2025 edition of the IAF Symposium took place on 11 February 2025 at the United Nations Office in Vienna, Austria, under the theme *"Space - Indispensable on the Agenda of Policymakers, Public, and Nations"* and explored ways to bridge gaps and engage diverse stakeholders in shaping the future of space in three insightful panels:

The Panel A entitled *"How to Engage Political Decision-Makers in the Space Debate?"* guided discussions on best practices for engaging political leaders in meaningful space dialogue. The key takeaways were the need for long-term strategies, effective communication with non-experts, stronger ties between space and digitalization, and teamwork in space diplomacy. The discussion reinforced the importance of making space relevant to the public and decision-makers alike.

The discussion on the Panel B *"How to Secure General Public Support for Space?"* concluded with a call to action to make space exploration more accessible and relatable, especially for younger generations. Panelists urged the public to recognize how space impacts daily life and the future of humanity, emphasizing the need to strengthen communication and engagement across all sectors of society.

The Panel C *"How to Embrace Emerging Countries in the Global Space Endeavor?"* outlined key motivations for investment in space:

- Industrial Growth: Space technologies create new markets and enhance existing industries, attracting traditional sectors such as machinery and software development.
- Valuable Data: Space-based resources support logistics, disaster response, and environmental monitoring, delivering concrete benefits to national development.
- Talent Attraction: The space sector serves as a magnet for young talent, fostering skills applicable to various technology-driven fields.

The conversation concluded by highlighting the mutual benefits of industry engagement with emerging space nations. Greater inclusiveness in COPUOS membership and IAF initiatives were advocated to enhance global cooperation in space governance.

IAF Spring Meetings 2025

Spring Meetings 2025

25 – 27 March 2025 | Paris, France

From 25 – 27 March 2025, the Bureau and members of the International Astronautical Federation (IAF) gathered in Paris, France for its annual Spring Meetings. Various events took place during the three days, including the selection of abstracts for IAC 2025; IAF "3G" Diversity events; committees' meetings including two sessions of the IAF Bureau; and IAF GNF sessions.

IAF Global Space Exploration Conference (GLEX 2025)

7 – 9 May 2025 | New Delhi, INDIA


GLEX 2025

GLEX 2025

Opening Ceremony

For three days, the 4th IAF Global Space Exploration Conference 2025 transformed New Delhi, the city dubbed as the heart of India, into an epicentre of the global space dialogue. Held under the central theme of Reaching New Worlds: A Space Exploration Renaissance, GLEX 2025 gathered over 1500 delegates from nearly 40 countries.

The opening ceremony was a homage to the richness and longevity of Indian culture and science and the achievements in India's space sector. Having started with the traditional classical dance performed to the music of Maithreem Bhajata, it highlighted the Indian legacy, *"where knowledge was a part of enlightenment, not just power"*, as Vimmi Choudhary, Master of Ceremony, reflected. The formal inauguration of the conference was marked by the lightning of the ceremonial Mangaldeep lamp by all the distinguished delegates invited to the scene, led by the guest of honour, Jitendra Singh, India's Minister of Science and Technology and Minister of Earth Science.

International Astronautical Federation (IAF) President Clay Mowry encouraged all the participants to take full advantage of the opportunities that GLEX 2025 presents. He also marvelled at India's stellar accomplishments in space and science, listing the achievements of the Indian space programme in the last decades. Congratulating ISRO for its successes, he summarized his remarks with a statement that *"India has proven itself to be a beacon of knowledge and inspiration in the cosmos"*.

The local host of GLEX 2025, Chairman of Indian Space Research Organisation (ISRO) V. Narayanan, extended his heartfelt gratitude to the International Astronautical Federation for organizing the prestigious event. He acknowledged the theme of the conference as perfectly encapsulating the spirit of India's ambitions for the space program. Reflecting on the impact of GLEX 2025, he underlined its importance of going beyond being an international conference but also a celebration of human ambition, ingenuity and collaboration in space exploration.

The importance of the reforms leading to deepening collaboration between public and private sectors in India's space program has been highlighted by Pawan Goenka, Chairman of the Indian National Space Promotion and Authorization Centre (IN-SPACe). With the bold target of increasing the budget from 8 billion dollars two years ago to the predicted 44 billion in 2033, *"India is the place to be in the space sector today with its infinite possibilities,* especially since the liberalization of the FDI policy and implementation of easy to *navigate regulatory regime in place"*, Goenka accentuated.

Josef Aschbacher, Director General of the European Space Agency (ESA), highlighted the importance of strategic autonomy and fostering international collaboration so that his institution can face both opportunities and challenges of commercialization and political upheavals while becoming a strong partner internationally. Building on the upcoming 50th anniversary of ESA, he reminded the audience of the over 40 years-long collaboration with India and Europe's contribution (particularly free data dissemination) to the development of the Indian space

sector. *"I am very happy and very proud to say that this program, which we implement together with the European Union, is something that Europe delivers to the world as its contribution to various partners and space agencies,"* Aschbacher summarized.

India's Minister of Science and Technology and Minister of Earth Science, Jitendra Singh, emphasized the importance India's government places on the space program, claiming that *"for India of 2025, the sky is no longer the limit"*. Looking back at the achievements of the sector and their implementation in multiple fields here on Earth, he remarked that *"space technology inputs have been utilized for the benefit of mankind and the ailing"*. Despite India's late start in space exploration, Singh claimed that the progress and milestones achieved are clear indicators that India is not only catching up but becoming a frontline nation. *"I have the confidence to say that India today is no longer only waiting for cues to happen. It is also in a position to offer cues to others, to its partners, and its collaborators"*, Singh added proudly.

In his video message, Prime Minister of India, Shri Narendra Modi, focused on the ancient wisdom of Vasudhaiva Kutumbakam, which translates to all the people of the world being one family. Referring to India's achievements as proof that *the human spirit can defy gravity*, he added that "space exploration *is a declaration of curiosity, courage and collective progress"*. Emphasizing that India's space journey is not about racing others [but] reaching higher together, the Prime Minister also mentioned the inspirational importance of having many female scientists leading the ongoing missions. He concluded by stating that *"India stands for dreaming together, building together and reaching for the stars together. Let us, together, write a new chapter in space exploration guided by science and shared dreams for a better tomorrow"*.

In the closing remarks, Christian Feichtinger, IAF's Executive Director, expressed his gratitude to all the speakers, host and co-host of the GLEX 2025 Conference, ISRO and Astronautical Society of India (ASI), as well as the local organizing committee and sponsors. International Astronautical Federation, a world-leading space organization, encourages cooperation and inspires forging new connections, which was mirrored in the executive director's call to reach the next frontier together.

The Opening Ceremony concluded with the official inauguration of the GLEX 2025 Exhibition Area, marking the beginning of the three days of vibrant exchange of ideas, discussions and reflections on the most critical topics in space exploration today, from democratization, commercialization, and sustainability to the regulations and plans for future endeavours of multiple actors in the sector, highlighting the importance of, as Mowry mentioned, *"ongoing journey of collaboration and innovation"*. ■

> "India stands for dreaming together, building together and reaching for the stars together. Let us together write a new chapter in space exploration, guided by science and shared dreams for a better tomorrow."

GLEX 2025

Plenaries

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HIGH-LEVEL SPACE LEADERS: The Future of Space Exploration: The Agency Perspective

GLEX 2025 witnessed three high-level plenary sessions, all of which have been dedicated to the future of space exploration as seen from and through different perspectives, *"which will give us a comprehensive look at what we can expect in the coming decades"*, said Christian Feichtinger, International Astronautical Federation (IAF) Executive Director and the moderator of the first session, which focused on the future plans of space agencies from Europe, Japan, India, Canada and China.

For the European Space Agency (ESA), represented by its Director General Josef Aschbacher, the future of exploration centres on LEO, Moon and Mars. Low Earth Orbit's primary goal is to remain one of the key partners in the ISS and the future commercial space stations. *"We are building Moon economy"*, Aschbacher said while elaborating on the second of the objectives. Foreseen plans for Moon exploration include Argonaut, Europe's lunar lander program and its compliment Moonlight, a future constellation for telecom and navigation on the Moon's surface and around. ESA also has a *strong participation in the Artemis program* and *a major big contribution to the GATEWAY* - commitments which, despite the planned budget cuts in the USA, ESA will uphold and *remain a reliable partner*. *Mars is the next destination, Aschbacher continued*. Besides two missions that are being currently developed, TGO and ExoMars, the Rosalind Franklin rover, which will be the very first one taking a probe from under the ground of Mars surface and analyse it on the surface of Mars, is planned to be launched in 2028. ESA's Director General also shared details regarding the recently published Strategy 2040, focusing on the importance of international cooperation in space exploration.

Kazuyoshi Kawasaki, Associate Director General for Human Spaceflight and Exploration at Japan Aerospace Exploration Agency (JAXA), similarly underlined the

> “Space exploration holds a profound intellectual significance in India’s space journey, inspiring millions of youths.”

importance of the international collaboration and sharing a common vision for space exploration, mentioning Japan’s signing of Artemis Accords in 2020, its participation in International Space Exploration Coordination Group (ISECG) and when sharing the future exploration plans, labelled as Roadmap 2040. Kawasaki stated that *“our vision is to create a permanent human presence [on the Moon] around 2040”*. The high probability of this vision’s success can be corroborated by the successful SLIM lunar lander mission with its pinpointed soft landing in January 2024. The next step in exploration is a JAXA-ISRO (Indian Space Research Organisation), LUPEX/ Chandrayaan-5 mission, with its objective *of searching for the water ice existence in the Moon’s South Pole region*. Asked about the sustainability of lunar missions, Kawasaki presented three folded perspectives: technological (permanent presence, as *it costs around one million dollars per kilogram to send to the surface of the Moon*), political commitment (with the utmost importance of international cooperation) and collaboration with all the industries (with the example of JAXA cooperation with Toyota on lunar pressurized rover).

“Space exploration holds a profound intellectual significance in India’s space journey, inspiring millions of youths”, began V. Narayanan, chairman of the Indian Space Research Organization (ISRO). Starting with India’s humble beginnings in space exploration in 1960s, he moved to the impressive plans for future lunar missions: the aforementioned ISRO-JAXA cooperation Chandrayaan-5/LUPEX sample return mission, followed by the crewed mission. India’s government has also given a go for the Venus orbiter mission, known as Shukrayaan, which is previewed to launch in 2028. Regarding Mars, India’s next step after having a successful Mars orbiting mission, Mangalyaan, will be a Mars landing mission. *“In the area of space exploration”*, Narayanan concluded, *“our hands are full”*. He also mentioned that all the data received from the planned missions will be shared with the international community. Expectations are surly high, especially after the groundbreaking lunar south pole landing of the Chandrayaan-3 mission, an achievement acknowledged with the 2024 International Astronautical Federation World Space Award, the recent docking experiments, circumnavigation of two satellites and ADITYA-L1 Mission, the last one being directed by female space scientist Nigar Shaji.

Canadian Space Spacy Agency (CSA) continuous involvement to ISS with Canadarm 2, plans long-duration stay of astronaut Joshua Kutryk mission and *science developments*. *“We are focusing a lot on health and medical research”*, Jill Smyth, agency’s Director for Space Exploration Planning, Coordination and Advanced Concepts, stated. Next year, as an outcome of NASA’s OSIRIS-REx Mission, CSA will receive part of the asteroid sample from Bennu. As partner in Gateway Program, CSA *is following very closely the budgetary decisions that are being made right now in the US*. Meanwhile, the work on Canadarm 3 continues, which can be seen as a testimony to *versatility of the robotics’ operations, capabilities and expertise in Canada*. As for the future of Lunar and Mars exploration, CSA is looking into *power generation and distribution, communications, and ISRO*. Smyth underlined that most of the agency’s portfolio is done in partnership, saying that *international collaboration is indeed part of our DNA in Canada*.

China also has big plans for space exploration for the coming 10 years, which will consist of three parts: lunar, planetary and asteroid exploration, revealed Weiren Wu, Director General of Deep Space Exploration Laboratory (DSEL) and Chief Designer of China’s Lunar Exploration Program. Lunar missions will include Chang’E 7 and 8 (their predecessor, Chang’E 6, is a winner of the International Astronautical Federation World Space Award 2025), which are designed for a soft landing on the lunar South Pole and establishing technical bases for the future International Lunar Research Station (ILRS). This massive project, developed in cooperation with 17 countries and 50 academic institutions so far, *“is the first of this huge-scale project that has been initiated and is being led by China”*. In addition, Wu said that China *would try to send the first Chinese astronaut to land on the surface of the Moon before 2030*. The planetary exploration will focus on returning samples from Mars’s surface (Tianwen-3 mission to be launched in 2028 and return in 2030-31) and *exploration of Jupiter and its satellites (Tianwen-4 mission, planned around 2040)*. As for asteroid exploration, the focus would be on scientific and sample discoveries and protecting Earh, *a demonstration mission around 2027*. Emphasizing the importance of international cooperation, Weiren invited interested parties from around the globe to join the ILRS project, *“as the Moon belongs to all human beings”*.

HIGH-LEVEL SPACE LEADERS: The Future of Space Exploration: The Agency Perspective

The second plenary in the series continued with the plans for future space exploration programmes of space agencies from the United Arab Emirates, Türkiye, France, Italy and Germany. The topics of utmost importance were discussed and focused on, as Tanja Masson-Zwaan, Assistant Professor and Deputy Director of the International Institute of Air and Space Law (IIASL), Leiden University, and session moderator highlighted, "reflection that the deeper we go into space, the more we learn and understand about Earth fragility."

Salem Al Marri, Director General at the Mohammed Bin Rashid Space Centre (MBRSC), acknowledged the short history of the UAE in space exploration, which started around 20 years ago with an early objective of Earth observation and aimed at, successfully, nationalization of the development of the technologies, for which getting the UAE private sector involved was key. Al Marri explained that the shift towards exploration was aimed at scientific gains and benefits, but we see the impact of exploration missions on the country and its people. The space exploration for MBRSC focused on three areas: Mars (mission sent in 2020, which is currently imaging and focusing on the Moon of Damos); Moon and sending robotic missions to the surface of the Moon; and human space flight (mainly in collaboration with international partners such as Roscosmos, ESA and the United States NASA). Two of the core of four astronauts have already

> “Space exploration is humanity’s dress rehearsal for survival, collaboration, and self-transcendence.”

flown, including the very first Arab long-term mission to the ISS, which was instrumental in getting the youth inspired and involved with the space sector. Currently, UAE is a partner in a planned Gateway station. The Director General stated that despite the potential cancelling of the mission, as UAE is smaller than other entities, we are obviously looking at how we can ensure that our participation remains positive.

For Türkiye their space journey started in the 1990s. Arif Karabeyoğlu, Faculty Member at KOÇ University in Istanbul, and CEO of Delta Space Technologies Corporation, as well Board Member of TUA, explained that *“it was in 2018 [that] we shifted gears to a higher gear as the Turkish Space Agency (TUA) was established”*. Following the president’s announcement of the space programme for Türkiye in 2020-21 with ten important objectives, out of which three were crucial. The first one was the first Turkish astronaut, who flew last year. “*There is* an impulse you get when you send an astronaut out”, Karabeyoğlu said. It is essential to keep this spark sustained to attract the youth and companies interested in space. The other two are composed of lunar exploration, and the third is a spaceport, *“as the capability to take things into space is required for independence. But the most important, in my opinion, is the private sector”,* Karabeyoğlu declared. *“But I don’t think you can make an impact by just having the government push things in space. I’m a keen believer in the commercial market*”, he continued, referring to the example of the United States.

Caroline Laurent, Director of Orbital Systems and Applications at Centre National d’Etudes Spatiales (CNES) emphasized that “*CNES’s work balances the European projects run by ESA with the national projects”*. Apart from being an important contributor to the development of the scientific projects for ISS, the principal CNES project is to *“accompany astronauts and (…) prepare experiments for (…) French astronauts*”. It has been done for both Thomas Pesquet in the past and now for Sophie Adenot, the second French female astronaut, who will fly in 2026 and, hopefully, will inspire many girls in France to get interested in a scientific career, Laurent explained. CNES is also involved in cooperation with MEDES (Institute for Space Medicine and Psychology), which is focused on space medicine. France also contributes to *“Artemis, sample return, Gateway, and Orion and ExoMars service modules. Of course, the national budget is more national when it’s related to the defence or competitiveness of our industry. Still, everything that is related to science, climate monitoring, astrophysics or exploration is all about international cooperation*”, Laurent summarized, giving the example of cooperation with NASA on Curiosity and Perseverance Mars rovers and with JAXA on the MMX mission (Martian Moons eXploration), DLR, UAE, ISRO (cooperation on human flights) and China’s Chang’E 6. “*We also have an inclusive project called SPACESHIP, where we work on mobility, food, nutrition, health, and energy for future lunar habitat*”, Laurent elaborated. While mentioning the international collaboration, as well as the country’s industry and start-up involvement, Laurent acknowledged that *“even if we can have a lot of money coming from private companies, and if we all are looking at what private companies can bring, I think cooperation between space agencies will still have a big future on exploration and Mars missions and planetary missions”*. Regarding the strict regulations in France for space sustainability, she mentioned that it is unfair

if the regulations apply only to French companies (also mentioning Japan's strict regulations). The objective is now to make these regulations "*become European and then maybe a world regulation at some point. This collaboration will show the public that we can share values, one of the most important being the durability and sustainability of the planet, the world, and space*".

"*The Italian exploration strategy focuses mainly on three areas: LEO, the Moon and the other celestial bodies, such as Mars, supporting both human and robotic exploration and straightening in-orbit operational capabilities*", said Maria Chiara Noto, Deputy Director of the IV International Affairs Directorate at Italian Space Agency (ASI). Like France, Italy contributes mainly to the ISS through the ESA and "*its long-standing partnership with NASA*". Regarding the Moon, Italy is "*developing the first lunar habitation module*". It was also "*one of the first countries to sign the Artemis Accords*". One of the most recent achievements in the area was "*the very first GNSS receiver for lunar use, LuGRE, which was launched a few weeks ago*". Partnerships with ESA, NASA, JAXA, and CSA dominate the exploration of Mars. "*And I think this legacy makes Italy a cornerstone in space exploration and a champion in international relations*", Noto summarized. Italy also contributes significantly to reducing the expertise gap in emerging space nations. According to Noto, this gap could be reduced "*through capacity building, technological transfer, and inclusive partnerships*", which ASI applies, for example, to the Broglio Space Centre in Malindi, Kenya, and the CONAE in Argentina.

Another example is "*the International Space Forum, an initiative supported jointly by the Italian Space Agency and the International Astronautical Federation. This year, it will be in the Philippines, involving all the emerging countries of the Southeast Asia region*". Referring to the space policy guidelines adopted in Italy last year, Noto underlined that it confirms "*space exploration as a national priority*".

In regards to space exploration, Germany, similar to France and Italy, also operates on two 'levels' – cooperation with ESA (as, for example, in the Colombus model) and "*what we do on, let's say, a national level, which is not national – its bilateral, multilateral with other states*", Walther Pelzer, Director General and Member of the Executive Board at German Aerospace Centre (DLR) explained. Another critical point is the European Astronaut Centre in Cologne, "*which was built with our partners from CNES from ASI and run by ESA*". The lunar facility was built in its vicinity, "*a most modern facility where the lunar surface is imitated*". Germany is also preparing for the post-ISS and "*fostering private investment and commercialization in this region*". All these factors, as Pelzer mentioned, provide "*a glance at the fact that exploration of lower orbit will be a stronghold in the German picture*". When it comes to the Moon, "*Artemis is one of our most important topics*", DLR Director General stated. Mars exploration is an example of bilateral cooperation with JAXA, as DLR contributes instruments to, for example, the Hayabusa mission. Pelzer claims to be an optimist regarding the budgetary cuts the US White House considers. "*Considering what this skinny budget would mean for science, exploration, and international partnership – and exploration is about global collaboration – I hope there will be some changes*". Pelzer concluded with another optimistic remark. "*I am more than happy that we successfully raised the political attention for space in Germany significantly*", as he mentions the newly elected government in Germany. He added that it "*is the first time we have 'space' on the nameplate of the ministry*".

The session moderator summed up the comprehensive discussion and the importance of different kinds of cooperation using one of her students' quotes, which said that "*space exploration is humanity's dress rehearsal for survival, collaboration, and self-transcendence*".

HIGH-LEVEL SPACE LEADERS: The Future of Space Exploration: The Industry Perspective

The last panel from the high-level space leader's series moved from the agency to the industry perspective. We *"move from inspiration and exploration to something with a clear market and exploitation focus"*, remarked Herman Ludwig Moeller, Director of the European Space Policy Institute, ESPI and the panel moderator. The session offered "global coverage from Japan, the US, Australia and Europe", focusing on public-private partnerships, the need for diversification and risk factors in the commercial space industry.

When asked to elaborate on the current NASA – White House tensions, Jacki Cortese, Senior Director for Civil Space at Blue Origin, acknowledged that "work with NASA will continue. However, our goal has remained unchanged since Blue Origin started in 2000, which is developing a set of commercial space capabilities that will increase access to space". The New Shepard and New Glenn missions can highlight an example of that objective. As for the lunar program, Blue Origin plans "to establish a lunar permanence: a permanent human presence on the Moon". The Blue Ring multiorbital vehicle, which is under construction, shares the same aim of unlocking "access to space for more people, science, and exploration". To date, Blue Origin has flown "58 people to space and back", a large percentage of whom were women and" firsts of nations". In this way, Cortese debunked the criticism of the latest New Shepard all-female mission as an example of billionaires-only privilege. Referring to the democratization of access to space as "an amazing tagline", she elaborated that the more people go to space, the more they get involved, interested, and passionate and consider the space sector's opportunity, which works for the benefit of all. I would just encourage us to, in times of uncertainty especially, to think outside of the box on ways that we can work together, she added.

Vincenzo Giorgio, Vice President for Institutional Marketing & Sales at Thales Alenia Space Italia and CEO of ALTEC, when asked about the challenges of cross-ocean trade, answered: "Of course, when talking about trades, you have to be always careful and following the line of what is really happening all around". He also elaborated on the importance of having a well-prepared business plan, "the capability of your products, and the possibility of fitting with the requirements if they are different". He also highlighted that the space agencies "will still be there and will always have their role", be it as an anchor customer or buying "the infrastructure itself", also acknowledging achievements of the very long-term projects developed by the agencies, such as James Webb Space Telescope or Cassini, space probe sent to visit Saturn. However, indicating sectors' future collaboration, "you cannot rely on the model that we've been working on within the last decades", Giorgio added, accentuating the difference between being a supplier and being a partner. "What you have to do yourself as an industry is to get prepared to be flexible and to have the possibility to approach the market segment whatever the requirements are", he summed up.

Focusing on the importance of the commercial companies in the space industry, Atsushi Saiki, Executive Fellow at ispace, inc., claimed that "what we are trying to do - and I think it is very important - I think the government, agency, commercial companies and academia, these are like the four wheels in the car (…) We have to make sure each wheel is facing the same direction". Drawing on his experience of cooperation with companies from around the globe and from different industries and using their technologies, he added: "I think it's our responsibility to find that and work with them". For now, ispace, inc. main revenue comes from "payload transportation services". Still, the plan is to extend it to "data business, which is a scientific and environmental business, which comes with the challenge of how to monetize it". The changes are expected also regarding funding. So far, the main flow come from the governments, which Saiki labelled as "lifesaving money that we are fighting to obtain", but to create a cislunar economy "more money should be coming from commercial side". He also touched on the complex issue of the insurance for space exploration performed by the commercial side.

David Caponio, Senior Vice President of Business Development at Vast, referring to the situation within the US government, said that it is being monitored closely, "especially as it relates to our major (…) objective, which is to win the commercial LEO destination program, planned to be achieved with our Haven 2 architecture", which was announcedduring the 2024 International Astronautical Conference. Other projects at Vast concern "Haven 1, the world's first commercial space station". For these programs, the anchor customer is NASA. Still, as Caponio clarified, "it is not an owner-operator, which translates to the need for collaboration with international space agencies around the globe". The biggest challenge, he pointed out, "is to do that in a commercial mindset". Heaven-2 is following that path thanks to its modularity, allowing it "to meet the demand of the actual market that manifests itself". All of these plans are to be done not as trailblazing but building on the decades of data and lessons learnt from the ISS, Caponio clarified. He acknowledged that NASA, ESA and JAXA are helping us to "develop (…) reactive commercial ability, but

what remains the focus ishaving a real product for profit generation. That is really the validation of the commercial model", he concluded.

Jeremy Hallett, Executive Chair of Space Industry Association of Australia, mentioned that "in Australia, and I say this without complaint, there is currently no government funding for space exploration" due to the lack of an industrial base and "social license". In such a situation, Australia's industry and academia can "leverage what other people are sinking billions of dollars into in terms of space infrastructure to develop leapfrog technologies that benefit life back on Earth", Hallett explained. The area currently being the most attractive for Australia is "the exploitation of a proliferation of microgravity environments to develop new technologies", illustrated with the example of the Plants for Space Program with its aim of developing "agricultural and horticultural products in microgravity". Touching upon the IAC 2025 guiding theme of Sustainable Space: Resilient Earth, Hallet emphasized the importance of the adjacent sectors – in the case of Australia, it is "the oil and gas and the mining sector". It is not only a sector that generates "about half of Australia's GDP" but also has decades of mining experience in harsh environments, especially in the Pilbara, which imitates the Martian environment. What is more, "a lot of mines are automated", an expertise that has already found its application in the space sector. The sector is also to be involved in a planned Australian-made rover, named Roo-ver, as a homage to the Australian kangaroos, which NASA would launch.

"The leadership at Intuitive Machines basically came out of NASA", mentioned Trent Martin, Senior Vice President of Space Systems, so it is unsurprising that "programs come and go within agencies". Faced with that knowledge, the way forward is, according to Martin, diversification of contracts. "As a company, we recognized that we couldn't just rely on lunar landers, so we intentionally bid on other contracts to diversify our portfolio", Martin elaborated. He added that it led to exponential growth of the company and the situation in which there is not "a single mission where I don't have some international collaboration". Martin pitched the reliability of commercial companies as they are contract-bonded, as they take on the risk of accepting "firm fixed price service-based contracts and having tailorable processes that fit within the industry standards". Another advantage, in Martin's opinion, is the fast investment return, but "you have to prove that you can do something quickly, or the markets will start to lose faith, and money will start to drop out", he rounded up.

This very dynamic session, with its panelists' absolute certainty of the upcoming changes in space exploration, has been summed up to the point by the ESPI Director and session moderator, who punctuated by saying: "It's no ISS times anymore".

> "I think the government, agency, commercial companies and academia, these are like the four wheels in the car (...) We have to make sure each wheel is facing the same direction."

New Frontiers: Evolution of Space Stations

"The future is now", stated Clay Mowry, President of the International Astronautical Federation (IAF) and the moderator of the panel discussion focused on the post-International Space Station scenario. *"The International Space Station represents the pinnacle of human cooperation in space"*, he added. Having been operating for 24 years, ISS has been recently joined by China's Tiangong Space Station and, soon, by India's Bharatiya Antariksh Station, not to mention all the other planned and ongoing commercial projects. *"We are witnessing a transition from exploration to utilization. Low Earth Orbit is no longer a destination. It's going to become an economic zone"*, the IAF president declared, inviting speakers to the discussion on the changing landscape regarding the future space stations.

Max Haot, CEO of Vast, is hopeful that the company will be chosen to replace the ISS. It became VAST's main goal merely 2 years ago, and their *"unique approach and strategy has been to develop an actual commercial space station without NASA funding in record time"*. Even though Vast's Heaven Space Station is going to be fully commercial, the company hopes to *"carry on the legacy of international collaboration, and the government will still be the number one revenue source for us to be viable"*. As a commercial business model, Heaven must bring profits, *"which can also be achieved with commercial activities that are not permitted in the ISS, such as pharmaceutical manufacturing and media, to name just a few"*. Reflecting on the success of Tiangong and the current geopolitical climate, he said it *"creates a real incentive to make sure we don't have a gap, and its motivation to make sure that we continue the international partnership"*. While the number one priority is, of course, safety, the challenge that VAST is facing is to *"have comparable services (to those on ISS) without the cost to the taxpayer and (...) being profitable while these new business models are being unlocked"*.

Whether national agencies are going to be able to take advantage of the new commercial space stations is *"a difficult and brand-new question"*, Sébastien Barde, Associate Director for Exploration and Human Spaceflight at Centre National d'Etudes Spatiales (CNES), hinted. The current regulation for European national agencies is that they cannot spend money outside their territories. However, *"we have to find a way because if we want to send our astronauts into space, we have no choice"*, Barde added. Europe's ambition is to become autonomous in space, which translates to huge costs. *"I think it's the right moment for us to really decide what we want to do in the future"*, Barde said. Contemplating lessons learnt from the ISS and considering the objective of lowering costs, his suggestion for future space stations is to *"simplify the access of microgravity to create a new market and decrease the cost"*.

Thomas Pesquet, European Space Agency's (ESA) Astronaut and CEO of Novespace, marvelled at the ISS, remembering that *"some people actually suggested the ISS was a candidate for the Nobel Peace Prize back in the day"*. Even though the idea was not feasible as the candidate must be an individual, looking at the recent history of the countries who ended up working together on the ISS must be considered a great achievement. Having been constantly operable for such a long time, the ISS is also a gold mine when it comes to suggestions for the new space station. *"We take it for granted, but it's absolutely unbelievable that it operates*

> “The International Space Station represents the pinnacle of human cooperation in space.”

every day. It’s been operating every day for so long”. As for the challenges for the future, Pesquet does not envision technical aspects because, as he said, *“we always manage somehow. But the political will and all that stuff is sometimes difficult”*, especially when considering the different needs of different European countries. But *“when there’s a will, there’s a way”*, he added optimistically, referring to the example of India’s dedication and long-term plan and China’s Tiangong Station success as *“an incentive maybe to do good things on our side as well”*.

India is to launch its own Bharatiya Antariksh Station before 2040, where the *“cutting-edge research will take place, and it will provide Indian as well as global researchers access to the lab at a reasonable price”*, claimed D.K. Singh, Director of Human Space Flight Centre at ISRO. The station is also to be *“a test bed for a springboard for the Moon and Mars”*, allowing testing *“of many technologies that you can’t afford to test far away from Earth”*, Singh clarified. *“We don’t want to reinvent all the wheels”*, Singh added when referring to the ISS legacy, while encouraging private companies *“to collaborate with the Indian entities”*. The biggest challenge for an agency’s station is *a huge upfront cos*t, which must be *“answered by the nation”* and justified in its return. India’s plan also includes providing an alternative for SpaceX, which, as for now, is the only way of sending astronauts to the space station. When asked about China and whether ISRO sees it as a competition, Singh answered eloquently: *“I don’t think we are competing with anybody. We have our own independent program driven by our own vision, and we want to do the things that are required for India.”*

Michael López-Alegría, Chief Astronaut at Axiom Space, Ax-1 and Ax-3 Missions Commander, reflected on the most crucial mission of the space station as being a continuation of *“human presence in Low Earth Orbit”*, which is completed with conducting world-class research and being *“a source of inspiration for people around the world”*. Not to forget, López-Alegría added, the value of international cooperation, half-jokingly adding that the ISS is the only place where Russians and Americans are getting along. The business model for Axiom Space remains *“pretty similar”* to that of the ISS, but to guarantee its profitability, other countries, researchers, and individuals would need to be added to the current ISS users’ pole. He also pointed to the additional revenue sources, such as product placement, movie shooting, and other *“purely commercial activities”*. As not permitted in the ISS, *“that is a giant hole that we would like to fill with our other customers”*, López-Alegría clarified. A big challenge is also to make sure that the new space stations must be *“evolvable so as to be able to update it continuously”*, he stated, adding that as for the Artificial Intelligence use so far, he can potentially see

its applicability for the ground control only. Referring to the question of China, the Chief Astronaut thinks that the Chinese station and the Chinese space program are huge motivators in the US. Simultaneously admitting that competition is seen there in terms of “Space Race 2.0”.

Roberto Provera, Director of New Initiatives and Customer Solutions Development, Exploration and Science at Thales Alenia Space Italia, as the biggest challenge in the changing scenario regarding the shift to the commercial space station, identified the *“change from [being] a supplier to [becoming] business operator”*. Referring to the comment of Sébastien Barde, who mentioned the issue of expenditure in the ‘local’ markets, another question is how, *“at the industrial level and agency level, we can have a model in which the market becomes global”*, giving the solution of barter as the potential mechanism for allowing Europe to have *“a visible piece of a commercial station. I think, as Europe, we should look at what India and China are doing in looking at the possibility of having their own systems”*, Provera added. He also said that *“business costs, technical safety and legal cannot be tackled individually”*, and ensuring a private company’s mission, and not only the launch, is *“quite hard, at least in Europe”*.

The very dynamic plenary also tackled the still unanswered questions regarding AI utilisation in the future space stations, debris responsibility issue for, especially, commercial programs which are not limited by the regulations so far, and safety issues, among others. What we are witnessing now *“is a relay race where we’re passing the baton from one space station to another. We’re improving as we go from government to industry, from legacy platforms to new ventures, from exploration to a sustained presence in orbit”*, summarized the International Astronautical Federation President.

Next Stop: The Moon and Beyond

The third plenary, moderated by Pascale Ehrenfreund, the President of the Committee of Space Research (COSPAR) and Research Professor of Space Policy and International Affairs at the Space Policy Institute/George Washington University in Washington DC, witnessed a very active audience's participation, with many questions on different topics regarding the space exploration asked. *"We are really standing on the threshold of a new era of space exploration"*, Ehrenfreund stated, quoting the BryceTech analysis, which predicted *"150 missions to the Moon and cislunar regions, as well as the surface of the Moon by 2034"*. While we are preparing for all the next steps of exploration, what must not be forgotten, she stressed, is that "the Moon is, actually, a part of the Earth", and while, of course, it can serve as *"a gateway into the solar system"*, it is also a 'gold mine of information' regarding *"crucial insights into the origin of our solar system, the formation of our planet Earth, and also the roots of our own existence"*, Ehrenfreund said.

The session kicked off with a question regarding the most significant milestones regarding space exploration in the speakers' organizations.

The point that needs to be stressed, highlighted by Daniel Neuenschwander, the Director of Human and Robotic Exploration Programmes at the European Space Agency (ESA), is *"that we cannot see the Moon in isolation"*. At ESA, he continued, *"we see it in synergy with low Earth orbit, Moon and Mars together"*. What remains crucial, as the *"exploration is about cooperation"*, is to remain *"a reliable partner, as this is a mandate we have from our member states"*. Neuenschwander continued to mention that there are *"key milestones at every destination"*. One of them is ISS, and ESA wants to be able to fly its astronauts there by 2030. What is the most fundamental, he persisted, is transportation because *"before going to the destination, you must have your own means of transportation"*. LEO cargo return service program is *"the pillar of the transportation capability"*, while another milestone, Argonaut Mission 1 and ExoMars program with the Rosalind Franklin rover, is identified as a landmark for Moon and Mars exploration. He also added, referring to the Artemis program, that this kind of model of cooperation *"will depend on capabilities and on geopolitics"*, insisting that, taking into consideration so *"many exploration ambitions across the world"*, there can be "no one-size-fits-all" approach for collaboration.

> "We are really standing on the threshold of a new era of space exploration."

Kazuyoshi Kawasaki, Associate Director General for Human Spaceflight and Exploration at JAXA (Japan Aerospace Exploration Agency), identified *"the expansion of the human presence in the vicinity of the Moon"* as one of the major milestones. There are many missions carried by JAXA with scientific objectives, but for the developments in the Moon exploration development, *"key milestones are a successful mission of SLIM"* (Smart Lander for Investigating the Moon) with its pinpoint landing and LUPEX mission, *"planned in cooperation with India"*, which will focus on *"water ice existence in the Moon's South Pole region, which will contribute to sustainable activities on the lunar surface"*, Kawasaki explained. He also stressed the importance of incorporating non-industry actors into the field of space exploration, referring to the Sora-Q miniature rover on the LUPEX mission, which *"was created in cooperation with a toy-making company, Tomy"* and Toyota, for a *"pressurized rover for the Artemis mission"*.

Plenary 3

"During the last 20 years, we had very successful collaboration programs with Russian instruments on foreign spacecraft, and the one main result related to exploration is water ice maps for the Moon and Mars", said Anatoli Petrukovich, Director of Space Research Institute (IKI) of Russian Academy of Sciences, leading Russian academic institution for fundamental applied space research and exploration. In addition, there are two ongoing Russian science missions: an X-ray observatory and *"two ionospheric sats for space weather studies"*. Regarding the Lunar program and the unsuccessful landing of Luna-25 in 2023, Russia is planning the next missions in the next year, *"given that it will be approved in the upcoming government's approval for the next 10 years plan"*, Petrukovich clarified. There is also Russia's involvement with planned Chang'E 7 and Chang'E 8 missions, namely a dust counter instrument, which is crucial as dust is a *"very important part of the lunar exosphere, which will definitely affect any permanent operations on the Moon"*, he clarified. When it comes to the more distant plans, IKI, as an academic institution which has just celebrated its 60th anniversary, offered to the Russian space industry extensive science support for exploration programs for new space station and for long-term projects. In the meantime, the institution is also actively conducting a vast outreaching program, which includes, inter alia, the Museum of Space Science and Technology, Petrukovich concluded.

Nigar Shaji, Associate Director, U R Rao Satellite Centre at ISRO, explained that India's space program *"has been tailored to two goals. One is to benefit countrymen through space technology"*, and the second is *"to inspire and motivate the younger generation of the country"*. To achieve these objectives, two parallel programs are being carried out, namely lunar exploration and human space flight with the Gaganyaan program. After *"India's foray into lunar exploration"*, which started in 2008, all of the following missions have *"technological and scientific objectives which ensure a steady progression in complexity and capability"*, performing the experiments on *"in situ resource utilization, manufacturing, plant growth radiation and temperature profiling"* needed for establishing a habitat on the Moon, with a culmination of astronauts landing on the Moon with by 2040. India is also planning to complete the space station by 2035, and *"interlay these two parallel programs, we have a Mars lander orbiter around Venus and an exoplanet mission"*, she added.

With a nod to Neuenschwander, Vincenzo Giorgio, Vice President for Institutional Marketing & Sales at Thales Alenia Space Italia and CEO of ALTEC S.p.A highlighted the importance of *"the vision of exploration as one real experience"*. As for the milestones achieved by his organization, Giorgio named its *"major role in manufacturing the habitable volume of the International Space Station"*, 40% of which has been built by Thales Alenia, and TGO's (Trace Gas Orbiter) involvement with ExoMars mission, which has been *"orbiting around Mars since 2016 and performing perfectly"*. When it comes to the lunar missions, plans include cooperation with ESA and *"international partners, such as MBRSC"* (Mohammed Bin Rashid Space Centre), as well as the Rosalind Franklin Mars mission in 2028. Reflecting on the agencies' and commercial companies' cooperation, he stated *"everything comes from the fact that we acknowledge the fact that we are part of a puzzle, that we develop technology, and that our agency is making the strategy"*. But what should be highlighted is that the technologies developed can also be used for other missions and programs, which *"leads to the conclusion that those kinds of missions and adventures are mandatorily done by international cooperation"*, Giorgio concluded.

When talking about Airbus's milestone achievements, Pierre-Alexis Joumel, Director of International & New Business - Space Systems at Airbus and General Secretary at EURO2MOON, divided them into those focused on low Earth orbit, Moon and Moon surface. LEO includes involvement with the ISS and a contribution to the Colombus module, as well as the current parallel engagement with *"the next generation of commercial space stations"* supporting the Starlab company. It is *"a very global concept"*, Joumel added, *"as it is supported by the US company with Voyager, Airbus in Europe, a Japanese company with Mitsubishi, and in Canada with MDA"*. When it comes to the Moon, the focal point is participation in the Artemis program *"together with Thales and Arian, with the work on the European service module attached to the Orion capsule"*. Airbus is also *"developing technologies to extract pure oxygen metal from lunar regolith"*, finding ways in which it can be used, and working on a 3D metallic printer, which is currently being tested in microgravity at the ISS. *"In parallel, we are also adapting to the moving environment and diversifying partnerships we have all over the world"*, Joumel concluded.

Following the introductory question, the audience asked about the key technological challenges which must be addressed to make it possible for humans to land on the Moon. While ESA's Director of Human and Robotic Exploration Programmes divided the difficulties into those related to transportation (recalling that *"today, no US astronaut is flying back to the Moon without the European propulsion system"*), crew safety and *"responsible exploration"*, Nigar Shaji from ISRO accentuated the *"psychological aspects of the crew"* as being much more important than technological issues, to which we always manage to find solutions. At the same time, Giorgio highlighted the importance of the *"ability to operate, maintain and ensure the logistics"* while working *"hand in hand with the astronauts"*, who, in the end, would use and live in those infrastructures. Not less crucial was a point made by Joumel from Airbus, who reflected on the issue of sustainability, for achieving which the ability to use local resources *"to "develop energy and telecommunication"* is needed, as he identified this technology as Europe's *"key contribution to the international program"*.

Unsurprisingly, some questions were asked regarding AI and the sustainability of Moon travels. Regarding artificial intelligence, JAXA representative highlighted the supportive role of AI and robotic missions for human activity, stressing that as we do not know enough about what can happen on the lunar surface, the final decisions will be taken by humans. Anatoli Petrukovich mentioned that two years ago, he would have agreed, but with the recent *"big burst in robotics and artificial intelligence, I should say that humans on the Moon would fight for their role with robots"*, he said facetiously, also mentioning that the added value of the robotic mission would be its lower price, as *"robots need not be returned safely"*. Vincenzo Giorgio suggested that we should not see robotic and human missions in competition. *"You have to get your results by whatever means, either human or robotic, and you have to have an efficiency in what you want to get in return for it"*, he added. AI, in his view, will be mostly useful in ground support operations for now, but "you don't leave AI playing a critical role in the safety of the human space flight module". The issue of sustainability, as observed by Pascale Ehrenfreund, is crucial, especially for younger generations, and hence, there is a need for some regulations regarding the issue. However, Daniel Neuenschwander observed that regulations alone might not be enough. He reminded ESA's zero debris charter and the fact that a sustainable mission might mean accepting *"that we reduce some capabilities of a mission in order to make sure that you enable sustainability, but that's a choice"*, and *"also, if you think in purely commercial terms it is a competitive disadvantage"*, highlighting the different framework for different industry players. IKI's director added to the discourse, stating that *"every step on the Moon, any trace of any wheel, will stay there for millions of years, so we also need to think about how we will move on the Moon (...) otherwise, there will be no place for a nice picture"*. From the commercial perspective, *"we are not thinking about the economic aspect of debris mitigation, but this has an impact on business cases as well"*, said Pierre-Alexis Joumel.

This very dynamic session also touched upon previously discussed issues of budgetary cuts and international collaboration, as well as the reflections on the most exciting parts of space exploration, with answers ranging from improving the peace in the world, inspiration for young generations, inclusion, science progress that will *"reshape our views about the origins of the universe"*, to name just but a few. Interesting times to be alive for, there is no doubt about it.

Outer Space: Exploration for All

"The theme of this session resonates with the theme of or the objective of this particular conference, as it captures two things: the global as well as the spirit of shared space exploration", observed Rajeev Jyoti, Director Technical of the Indian National Space Promotion and Authorisation Centre (IN-SPACe) and the fourth plenary session moderator. If we look back, we will realize that space exploration happened only because of two things: one is because of fostering innovations, and the other is collaboration. The two most awe-inspiring examples are surely the International Space Station (ISS), which demonstrated the multinational effort involving NASA, Roscosmos, ESA, JAXA and CSA and had been serving for many years already as a hub of scientific research and technology development as well as the James Webb infrared telescope. The remaining question, as we are *"witnessing a paradigm shift from space 3.0 to space 4.0 and the commercialization of the space sector"*, what is next now? I will urge all delegates who are sitting here in the audience to imagine their role in this shared future and be part of it, Jyoti encouraged the audience.

The first round of questions focused on the status and a summary of the plans for space exploration, directed to the representatives of space agencies of India, Europe (ESA), Rwanda (RSA), Australia and Luxembourg, as well as a private mission astronaut about his Rakia mission.

Henriette Cyuzuzo, International Cooperation Analyst at the Rwanda Space Agency (RSA), said that the spark for creating the government institution in 2020 was a *"small working group"* and the launch of the first satellite in 2019, achieved with our international partners. RSA's pivotal mission is *"to use space for socioeconomic development"*. It is crucial, especially since *"there is still a gap in the sub-Saharan African continent on the infrastructure of the space sector"*, which made the RSA *"see a need to have our first teleport"*, which *"is helping in different sectors to inform some of the decisions"* that must be made, she continued. The agency is hence *"focusing on both upstream and downstream"* applications, with examples of providing connectivity to remote rural areas and solutions supporting *"different sectors, like agriculture, urban planning, disaster management, and many more"*. According to Cyuzuzo and RSA, what is essential are *"good policies and regulations that facilitate or work for the government*

> "Sometimes sustainability can come at a cost, and we do need to realize that but if we don't do something now then it will be too late."

of Rwanda and the private sector". It was precisely why Rwanda approved a *"tenure strategy"*, with the investors in mind and streamlining their operations in Rwanda. There's *"nothing you're going to achieve in space if you don't allow the private sector to invest in your country"*. Another critical issue, as *"space technology is relatively new on the African continent"* and hence hard to oversee, is the need for skills development. Despite the obstacles, *"Rwanda wants to be a part of the global conversation. Because of that, it is very thankful to the International Astronautical Organization"* for the opportunity to host GLOC 2026 in Kigali. *"We understand that our country, Rwanda, is a landlocked country, but not a space locked one. This means that we are looking for international collaboration. We are looking for partners that can partner with us with a shared mission and vision"*, Cyuzuzo stated when referring to spacefaring nations' role in helping other countries.

"What we can do together, none of the 22 countries could do alone", stressed Eric Morel de Westgaver, Director of European, Legal and International Matters at the European Space Agency (ESA), referring to his agency's strength of uniting and *"being a tool for member states to cooperate together"*. Mentioning the ESA's "reinforcing our links with India", he moved to the subject of ESA's science program, which, cooperation-wise, *"is something absolutely unique because it is managed by the scientist for the scientist"*. Yet another example is ESA's participation in the ISS – out of 15 countries involved, 11 *"are represented by ESA, making cooperation the centre of the DNA of space in Europe."* When asked about innovative technologies and new ways of space exploration, Morel mentioned the *"Leo return cargo vehicle. The idea is to go to the space station but also to bring back cargo"*, he explained, adding that it is not only the technology itself that is crucial because *"it is important how we do it"*. Traditionally, the agency *"developed programs by putting on the table the requirements, telling the industry how to do things and pushing the industry to make development programs. Here we are doing it completely differently"*. The new approach is based on providing a service by a given deadline, with *"competition on that basis. We have selected two teams, and the aim is to maintain this competition. This is really a new way to look at the space development from an agency point of view"*, he said. A similar approach was applied to the LightShip propulsive tug initiative to provide affordable access to Mars. *"On one side, [we are] giving more responsibility to the industry [as we are] looking for a service, and on the other side [we want to] to offer the scientist a way to do it in a more sustainable and also cheap way"*, Morel summarized. Safety continues to be a crucial and *"multi-domain element"* with all the new developments. Morel highlighted three factors: space debris (which should be a *"global responsibility to reduce the debris"*, as an aspect in which ESA wants to be *"a model agency"* with its zero debris charter), physiological and psychological health for extended human stays, and life support (*"with water, food, waste and oxygen management being essential). When you think in terms of collaboration, the important point is interoperability of those systems"*, Morel concluded.

Bob Lamboray, Senior Manager for Lead Exploration and Space Resources at the Luxembourg Space Agency (LSA) and Strategic Advisor for the European Space Resources Innovation Centre (ESRIC), provided a brief overlook for Luxembourg, whose space activity started in 1985 and focused on satellites, with *"SATCOM becoming one of the largest or the largest satellite operator"*, recently opening also an office in India. Twenty years later, Luxembourg *"became the 17th member state of ESA, with the idea to develop the space industry beyond satellite communication and support the European effort to develop space"*. The next milestone was marked in 2016 with the space resources initiative, which *"aims to contribute to the peaceful exploration and sustainable utilization of space resources for the benefit of humankind and to create a framework where commercial operators can actually operate and use space resources"*, which unsurprisingly come with many regulatory challenges, Lamboray explained. In 2018, the Luxemburg Space Agency was established, and it *"sees our role more as an enabler. Maybe it would be more accurate to say that we are a space development"* agency, which translates to not having *"our own space missions or space technology, but we believe in the future of commercial space. We see a big opportunity to diversify our national industry and economy through space, and we help the sector innovate and create the products and services for space"*. LSA's primary goals consist of *"driving economic growth, creating jobs, helping local industries to innovate, finding and training talents, and working with ESA"*, Lamboray recapped. He also elaborated on the challenges and the ways he supports the commercial side in his role as Strategic Advisor at ESRIC. *"On the innovation side, we support [the companies] in developing lunar surface mobility to complement their lunar transportation services and help them actually operate different activities on the lunar surface. For that, we have different R&D contracts through ESA. On the enabling side, as a country, we also want to provide the right legal and regulatory frameworks for [the companies] to operate"*. To clarify this concept, Lamboray brought up the example of ispace Luxembourg's sample return mission, which is to be the first that will work under Luxembourgish *"law, and really a nice first example of how the right legal framework supports industry to get also investors"*. The success of the approach is highlighted by the growth of *"different entities active in space"*, from roughly 20 ten years ago to more than 100.

"Rakia is a not-for-profit organization dedicated to advancing the space ecosystem, inviting everyone to join, stated Eytan Stibbe, AX-1 Rakia Mission Astronaut. *"To explore the universe, a certain level of courage and curiosity is required"*, he continued. The Rakia mission, which was part of the Ax-1, the first private astronaut mission to the ISS, launched 5 years ago. Stibbe admitted that human presence in space attracts more interest and awareness, quoting Sophocles, who, 2,400 years ago, said that *"numberless are the world's wonders but none more wonderful than men"*. He extended it by saying: *"and teamwork, obviously"*. Rakia's mission research focused on making a high-quality lens in space from a liquid polymer (which resulted in water lenses) and the phenomena in the atmosphere, like aurora and various

electrical discharges in the upper atmosphere. All of Rakia's activities are measured by their contribution to the United Nations' SDGs, he added. As the Indian Astronaut Shubhanshu Shukla is preparing for the Ax-4 mission, Stibbe shared his experience as a commercial mission astronaut. *"It's fortunate that private astronauts had the opportunity to build their own program. Our program was built: 80% of the time was spent on research, art creation, and education outreach, and only 20% was left over for other stuff. I wish Shukla a successful mission and understand the magnitude of his responsibility as he represents the largest nation on Earth. I also assure you that he has a very busy work plan, requiring him to focus during the whole mission"*. Reflecting on space missions' commercial potential, he also admitted that it hasn't yet been proven that a space station can survive on a commercial basis. All the companies are struggling with that issue. Stibbe said the first step to lowering the cost would be to have more launchers available.

Victor Joseph, Associate Scientific Secretary and Director of Technology Development & Innovation at the Indian Space Research Organisation (ISRO), referring to the morning's highlight lecture, confirmed that the *"Indian space program has always been rooted for the benefit of the common person and it that's relevant even now"*, as the space data have a direct effect on lives on earth, be it in communication, navigation or agriculture. With more than 50 satellites currently in orbit, *"with the aim of almost triple it to 150 plus in the five years"*, India, *"with the support of the growing private sector"*, was able to achieve all the latest successes and milestones, such as Chandrayaan missions, docking and solar exploration and plan for the future Chandrayaan and Gaganyaan expeditions, development of the space station and *"a roadmap of Indian landing on the Moon by 2040 using our own rocket, satellite and the spacecraft modules"*. To achieve that, ISRO is working on a *"new launch vehicle, which will be cost-effective"* and reusable. One of the best examples of innovative technologies and cost-effectiveness is POEM, the PSLV Orbital Experiment Module, which utilizes the upper stage, allowing for the performance of even more experiments. *"Across ISRO centres, we are right now running almost 2,000 plus technology development programs, as independent access to space gives a strategic advantage to a nation"*. The approach has also been *"a key element in how we are able to contain cost and how we are effectively controlling the cost over the years"*, Joseph stated.

"We are witnessing a democratisation of space exploration like never before, as many countries enter the arena for the first time and as we move towards the privatisation of space with governments no longer the only ones at the helm", declared Lisa Vitaris, IAC Sydney 2025 Director at the Space Industry Association of Australia (SIAA). *"It's truly an exciting time for the global space ecosystem"*, she continued, using her speech also as an opportunity to congratulate the Korean Aerospace Administration (KASA) for establishing their national space agency last year and the African Space Agency's inauguration a month

ago. Highlighting the new players entering the field, she mentioned that in 2024, *"Katherine Bennell-Pegg became the first Australian citizen to train as an astronaut under the Australian flag at the European Space Agency's Astronaut Centre"*. In 2025, Norway sent its first astronaut, Jannicke Mikkelsen, to space on the Fram2 mission with SpaceX. We have also witnessed Guatemala's and Botswana's satellite launches, which would not happen without international cooperation, which is a key to success. *"We all have our unique advantages and strengths that we should leverage as much as possible"*, Vitaris said. As for Australia, it has witnessed significant global collaboration through government agencies, the private sector, partnerships, and academia. As an example, she mentioned the MOU signed between the Australian Space Agency and ISRO in 2021, which resulted in Australia's formalising its support of India's Gaganyaan missions, which will allow our agencies to work together on crew and crew recovery and both countries' industry collaboration through the international space investment and 'MATES' scheme for students' exchange. What is needed, Vitaris urged, *"is that we should further encourage our respective governments to provide more opportunities such as these for our industries to collaborate. As an industry association, we are committed to breaking down barriers for our organisations to do business internationally"*, she clarified, inviting everybody to participate in the International Astronautical Congress 2025 in Sydney. Another important point is policy initiatives for international collaboration for sustainable space exploration. During the COPUOS Legal Subcommittee, which was taking place at the same timeframe as GLEX 2025, *"our esteemed Australian professor Steven Freeland is actually proposing the first draft of the resources policy for space to ensure equitable access to space resources in lunar environments. I think having the policies and guidelines are useful, but then, equally [important is] how do we take it one step further,* because *"sometimes sustainability can come at a cost, and we do need to realise that, but if we don't do something now, then it will be too late. To do that, we need to make sure that everyone is on the same page, everyone subscribes to it, and there's a practical way to actually make use of these guidelines"*, Vitaris summarised. ■

GLEX 2025

Highlight Lectures

New Frontiers: The Democratization of Space

Taking on a vast topic of the democratization of space and focusing on *"commercial space and private sector space and opening space up for more and more stakeholders"*, Sirisha Bandla, Vice President of Government Affairs for Virgin Galactic and Astronaut, as well as the keynote speaker of the first Highlight Lecture, took the audience on the trip through both personal and commercial space exploration history.

Bandla, who wanted to be an astronaut for as long as she could remember and did everything to become one, had her dreams crushed when, in 2004, despite following the 'traditional' training line, her deteriorated eyesight *"disqualified [her] from becoming a NASA astronaut"*.

Luckily for Bandla, in the same year, 2004, Scaled Composites won the Ansari X Prize with its experimental spacecraft SpaceShipOne, showcasing *"private sector ingenuity but also sustainability"* and, in other words, a game-changer for commercial human space flights. It has inspired Sir Richard Branson to create Virgin Galactic. Bandla has flown on the winner successor, SpaceShipTwo, a mission which was aimed at *"testing the interiors and experience for our customers in the future"*, as well as to *"test the capability of this vehicle to conduct microgravity science"*, which was specifically Bandla's responsibility during the mission.

Her dream coming through has resulted from a long history of commercial companies entering and participating in space exploration endeavours. It started with Telstar 1, *"a satellite funded and built by a private entity, launched in 1962"*. John F. Kennedy, the then US President, commented on its success as an *"outstanding example of the way in which government and business can cooperate in the most important field of human endeavour"*. What followed (after Syncom 1 and Syncom 2) was Syncom 3, a satellite launched in 1964, which *"was first deployed to geosynchronous orbit to be leased to the Department of Defence, setting up a public-private partnership, and which allowed to telecast the 1964 Olympic Games for the first time from Tokyo to the world. This was the beginning of building commercial capabilities and economies beyond our planet's atmosphere"*, Bandla continued while adding that the launching did not become commercialized earlier on due to multiple factors: *"the barrier to entry takes a lot of upfront capital"*, and she said teasingly, *"it's quite literally rocket science"*, pointing to the complexity of technology needed for its development. To *"add on top of that, you have to make innovations in not only the launch technology but also manufacturing and operations to get something like that and be scalable and profitable for commercial companies. And you have to have a robust market to support the high cost of the service"*, she continued. Regarding launchers, the first commercial was Ariane 1 in 1979, which *"was designed to send a pair of satellites to orbit on a single launcher, bringing the cost for the launcher and for the customer down"*. The real growth of commercial involvement can be noted from the 2000s, when SpaceX, Virgin Galactic and Blue Origins were founded and when we *"started seeing access to space open up"*, especially as it enabled human space flight.

Bandla emphasized the importance of the democratization of human space flights because *"there is absolutely no way you can go to space and see the planet and not come back and feel like you are empowered, inspired, and have a perspective shift on your life"*. She drew from her own experience when, after going to space and seeing how small our planet is from that perspective, she realized not only that it is her favourite planet but also that seeing it like that is *"a good reminder that, when we're here, that we're anything but. And the life that we're living should be anything but small"*. As we are witnessing exponential growth in the number of people going to space thanks to the commercialization of human space flights, we can also, according to Bandla, see *"a diversity of reasons"* for going to space, be it experience, work or research. Another crucial shift lies in the fact that we see *"diversity in the people going to space. They're not just engineers and pilots, but they're also artists, lawyers, communicators, and filmmakers, which allows us to see spaceflight through the lens of so many more people from so many different areas on this planet"*.

Before finishing her keynote and inviting everyone to participate in the upcoming panel on the evolution of the space station, Bandla stressed the point of wanting *"to give a nod to the government. This isn't commercial versus the government. It is a partnership with the government"*. With commercial space as an enabler and with the cooperation with agencies, we are on the cusp of having more research developed in space, more technologies that would permit further space exploration and benefit our lives on Earth, and having more people going to space, she concluded her humoristic and insightful speech.

> "They're not just engineers and pilots, but they're also artists, lawyers, communicators, and filmmakers, which allows us to see spaceflight through the lens of so many more people from so many different areas on this planet."

China's Deep Space Exploration and International Cooperation

The second in the series of the Highlight Lectures focused on China's planned deep space exploration missions and the opportunities for international cooperation. Wang Zhongmin, Director of the International Cooperation Centre at Deep Space Exploration Laboratory (DSEL), a subsidiary of China National Space Administration (CNSA), kicked off with a short summary of China's space exploration. "Over the past 20 years, China has successfully implemented seven deep space missions", which include lunar and interplanetary explorations. It gives China, as Wang mentioned, a 100% success rate in the past two decades, making China "the first country in the world to have reached this successful record". This proud statement was supported by the detailed account of China's successes of the Chang'E, Tianwen and Queqiao programs, which resulted in, just no name a few, the first-ever soft lunar landing on the Far side of the Moon and bringing back the sample, performing soft landing on Mars and 3D lunar imaginary and Lunar Global Map.

Not at all less impressive are the future plans, as China envisions not only the astronaut landing on the Moon by 2030, obtaining direct evidence of the existence of the Ice Water in the South Pole of the Moon, but also bringing back a first-ever Mars sample, sending exploration to Jupiter and beyond, constructing Near-Earth Asteroid Defence Mission, and probably the most impressive of it all, the construction of International Lunar Research Station (ILRS). The plan for the LRS is "the first time when China is leading" a huge international project, Wang disclaimed. The biggest challenge for lunar exploration is ground communication with the far side of the Moon – a problem that is being resolved with Queqiao relay satellites, with the "planned Queqiao constellation to provide communication for the ILRS".

As for the international collaboration, Wang declared that China "welcomes and invites every country in the world to participate in Chinese missions". He also mentioned that China has already provided a "piggyback opportunity for different kinds of scientific payloads" to many European countries, as well as Saudi Arabia and Pakistan. The same chance will be offered with upcoming Chang'E-7 and Chang'E-8 missions, scheduled for 2026 and 2028, which will land in the South Pole of the Moon. Similarly, any country in the world can apply for a loan for the lunar sample brought by Chang'E-5, and the same process will soon be available for the sample brought by Chang'E-6 from the Lunar South Pole. The biggest international collaboration will inevitably evolve around the ILRS, for which China has a "Triple-Five Target", which refers to the plan that "in the next 10 years, we would like to invite more than 50 countries, 500 international academic institutions and also more than 5,000 researchers and engineers to participate" in the project. "We welcome every country to join us in ILRS", Wang declared. So far, the project gathered 20 countries and over 50 international institutions. As space exploration is a shared endeavour, Wang invited all to "participate and work together to build a community with a shared future of humanity in outer space and contribute to expanding human knowledge, enhancing human welfare and continuing human civilization".

> "We invite everyone to participate and work together to build a community with a shared future of humanity in outer space and contribute to expanding human knowledge, enhancing human welfare and continuing human civilization.""

Space Exploration to benefit Humanity on Earth

Before starting his speech, BN Suresh, Chancellor of the Indian Institute of Space Science and Technology and the keynote speaker of the third Highlight Lecture, precautioned the audience that the subject he is embarking on covers a very vast area and that he has only half an hour to presents, he is "hopeful I should be able to do it justice".

The main thought underlying the presentation was the concept of space exploration's potential to help the average person, "the common man all over the globe, not just only spacefaring countries. I think the whole idea behind it is we should reach out and then try to help the whole humanity, the level of living, and those things that have to improve", Suresh claimed.

One of the aspects and outcomes of space exploration is its role in governance and "contributes very crucially to meeting the sustainable development goals (SDGs) defined by the United Nations", especially in the areas of Environment and Climate (with "systematic monitoring of the environmental changes advances in technologies for better understanding of climate"); Disaster Management; Agriculture and Education, as it provides the internet access to the remote areas. What also should be highlighted is the fact that there is "no other technology in the globe that has inspired or attracted the younger generation" to pursue careers in STEM.

There are countless advances in numerous fields of communication, water resources, disaster management, and navigation, just to mention a few, which have been achieved through space exploration endeavours. Having said that, the future is not without its challenges. Suresh highlighted two major "impediments to space exploration: mass and volume. It is extremely important that we must develop the technology to bring down the cost", a trend that has already started with the commercial players entering a field, which can be seen with a surge in space activities and launches. Taking the year 2024 as an example, he mentioned that 261 launches happened, marking "nearly exponential growth, of which 145 were done by SpaceX alone".

While there are many ambitions and plans, we cannot forget about the underlying principles of space exploration's

> "It is easier said than done, but today's fiction is tomorrow's science, tomorrow's technology. I think we must remember that."

benefits and scientific advancement to "be distributed to everyone in a proper manner"; it should only have peaceful goals: the responsibility "for national space activity whether it's governmental non-governmental" and liability "for damages if any caused by on the space objects". What should not be forgotten is that nothing else has "triggered innovation to the maximum extent" and forged strong international commitment and cooperation in space and space exploration.

What is needed for a fruitful future is, besides lowering the costs, "linking all these activities and developments to challenges on Earth". At this point, Suresh touched on the important yet usually overlooked factor of the importance of social sciences in helping to create the link between all the above-mentioned advancements and their benefits to society. The benefits are numerous, he continued, listening to the "spin-off technologies for medicine and communication, infant stage technologies to mitigate the space debris problem, development of cleaner and more sustainable launch technologies, resources extraction and international collaboration". In all this, public awareness is crucial, as it "guarantees support and continuation", Suresh pointed out. There is also an impact space exploration has on the economy, and an example of India, with its ambition to increase its participation in the global space economy from the current 2% to 20% in 2047, "a year which marks the centenary year of our independence", can be a good example.

Again, with the big progress comes big responsibility and certain guidelines should be respected by "all stakeholders for healthy space exploration", Suresh continued, listing "a comprehensive economic database providing a systematic assessment of the environment, effective governance framework, defining and categorizing harmful contamination, policies and regulations, transparency and facilitating of international cooperation and collaboration as cornerstones. It is easier said than done, but today's fiction is tomorrow's science, tomorrow's technology. I think we must remember that", he added.

Suresh finished the keynote with what he labelled "some thoughts to ponder over". Just as the first people who started to travel with aeroplanes and those who first used the internet could not have predicted how deep the impact would be in a very short time, similarly today, there are not many people who realize that, relatively soon, space "economy might completely alter the way in which we live and work". But, as Suresh stressed, when it comes to benefits for the common person, "we still are in a very infant stage", especially because apart from a few nations who dominate space exploration today, the rest is basically cut out, and what is needed is "to give that helping hand and make sure they are with us, they are able to reap the benefits". He finished with a rhetorical question: "are we prepared to be part of this history"? ■

GLEX 2025

IAF Global Networking Forum (IAF GNF)

Global Networking Forum
Meet. Share. Connect.

The Global Exploration Roadmap: A Shared Exploration Path from LEO to Moon to Mars

The first of eight International Astronautical Federation Global Networking Forum sessions focused on the Global Exploration Roadmap, a flagship product of the International Space Exploration Coordination Group (ISECG).

Daniel Neuenschwander, Director of Human and Robotic Exploration Programmes at the European Space Agency (ESA) and formerly chair of the ISECG, in his keynote address, summarized the Group's goal of *"advancing space exploration to strengthen humanity's future"*, which is done voluntarily and with the fundamental principles of *"inclusiveness, flexible and evolutionary, stability and long-term vision, support mutual interest"*. Currently, 28 agencies work on the Global Exploration Road Map, which *"shows that exploration is at a crossroads worldwide. I think we cannot communicate enough about the benefits of exploration for humanity"*, Neuenschwander continued. He summarized his keynote as the former chair of ISECG and the Director at ESA by saying: *"Together, we will go further. Together, we will do it better for future generations."*

"We are the witnesses to a very much historic moment", said Tirtha Pratim Das, Director of the Science Programme Office at ISRO (Indian Space Research Organization), justifying the statement by adding that at this very moment, the *"major space agencies around the globe are gearing up in a more energetic way to explore the Moon and the Mars, and (...) the Low Earth Orbit"*. Alluding to India's past and upcoming achievements in space exploration, he focused on the plans for Bharatiya Antariksh Station, a modular space station to be launched by 2035, as it *"will open a lot of opportunities for international cooperation and development of fundamental science"*. He finished the statement with an optimistic remark: *"we will see the seed of doing something great in the coming few decades"*.

The following part of the session has been moderated by Stefaan de Mey, Strategy Team Leader at the European Space Agency (ESA) in ESTEC (European Space Research and Technology Centre), who invited the panellists to reflect on the *"technology as the enabling factor for exploration"*, the outcomes from participation in ISECG and the tangible *"benefits stemming from space exploration"*.

Pierre W. Bousquet, Deputy of the Associate Director for Exploration and Human Spaceflight at CNES (Centre National d'Etudes Spatiales), mentioned that as far as science is concerned, the most vital achievement of the Global Exploration World Map is that *"it's preserving*

science through exploration and scientific integrity". He elaborated on CNES and French scientists' involvement in several missions with NASA, ESA, and recently, CNSA, highlighting that *"ISECG is all about collaboration"*. The results and experiments, both passed and planned, *"are very much in synergy with future human exploration"*, Bousquet explained, adding that the main focuses now are geology, exobiology and seismic monitoring, as they are all crucial for establishing human presence in both Moon and Mars. The benefits of space exploration findings can also be translated to the improvement of life on Earth – *"the echograph for remote ultrasounds"*, carbon and water recycling and treatment, which are being tested for a *"frugal approach for future human exploration or the algorithm developed [in space] used to identify patients which were in crucial need of critical treatment"* during Covid-19 pandemic are just a few examples, concluded Bousquet.

Bo Byloos, Manager Exploration and Science at Luxembourg Space Agency (LSA), concentrated on Luxemburg's engagement in commercialization oppor-tunities, *"as we have seen that these public-private partnerships are becoming really important"*, and so the agencies are *"trying to stimulate the industry to develop new services and new products"*. Examples in Luxemburg include a company that *"produced kilometres of fibre optics in microgravity"* and a Luxemburg-built rover through ispace Luxemburg. All these actions aim to stimulate companies for the outcome of *"lowering the barriers to access to space and the costs of going to space"* and consequently bring back all the results to be applied to life on Earth. For Luxemburg, she continues, the economic benefits are clear, and *"the main objective for commercialization is that it is happening in a collaborative spirit as well, contributing at the same time to talent development and growth of the skilled workforce that can work in our ecosystem, as it drives innovation and contributes to new discoveries both in life science, as well as plant growth and material research"*, Byloos finished.

The importance of ICECG in helping foster cooperation between well-established and emerging space agencies was explained by Silvia Ciccarelli from ASI's Initiatives for the Internationalisation and Promotion of National Space Industry, as it *"was created exactly with the spirit of enlarging the participation at the global level in the space exploration endeavour"*. Another importance lies in *"the focus on commercial partnerships"*, which indirectly *"facilitate the entrance of new actors, including emerging countries. ISACG promotes interoperability, common interfaces, standardisation and common architectures, and this, in the end, lowers the entry barriers and facilitates the participation of different partners"*, Ciccarelli explained, mainly as it also includes "the possibility of collaboration not only in space activities but only on the ground". She has also focused on international cooperation benefits, giving an example of the cooperation with ESA and NASA on the ISS as *"the opportunity to set up a strong industrial base recognised at the international level with many economic impacts and benefits"*.

> "Together, we will go further. Together, we will do it better for future generations."

Jill Smyth, Director for Space Exploration Planning, Coordination and Advanced Concepts for the Canadian Space Agency (CSA) explicitly explained the need for the ISECG by saying *"that space exploration is a vast, expansive endeavour, and no single nation can do it alone"*. Technology Working Group under the ISECG *"helps identify the technology gaps that are critical to achieving the objectives of the Global Exploration Road Map"*, she added, highlighting that it is also an opportunity to *"forge potential partnerships"*. For Canada, the most significant benefit of space exploration that can be applied on Earth is the same technologies that *"keep our astronauts in deep space safe and healthy: remote care solutions, food production and water filtration"*, which gain even more importance when considering Canada's natural conditions. The Global Exploration Road Map is a consequential aid, but "we don't stop there. It's really a continuous effort", Smyth summarized.

Kota Tanabe, the Director of the Space Exploration System Technology Unit of JAXA Space Exploration Centre (JSEC), mentioned that *"each space agency has its own specialty and a priority under some limitation of the resources"*. JAXA has been, for years, co-sharing the International Architecture Working Group, *"with the Lunar Surface Scenario as being one of the most important issues in the Road Map 2024, and includes cargo delivery, logistics for pressurized (...) or unpressurized crew mobility astronauts, (...) infrastructure, (...) communication and navigation"*. The plans do not end with the Moon, and *"robotic missions and human exploring missions to Mars"* will be the next step. As an example, that best shows the benefit streaming from space exploration, Tanabe pointed to the Kibo module project, which forms part of the ISS, as it is *"one of the examples showing how global cooperation in space exploration can support sustainable development across space for all, as well as providing space emerging agencies and countries with opportunities"* to be a part of the space exploration. Referring to the white paper published in 2024 by ISECG on the Benefits Stemming from Space Exploration, he highlighted the importance of translating the document to Japanese, with *"the aim of making it more accessible to the general public"*.

Axiom Mission 4: Building on the Legacy of Human Spaceflight

Few topics attract more public interest than a personal account of the experienced astronaut, which Michael López-Alegría, Chief Astronaut at Axiom Space, undoubtfully is.

Axiom Space has three main areas of focus: the building of the first commercial space station, the development of new space suits, and private astronaut missions, which were the focal point of the session.

"The idea of a private astronaut mission was initiated by NASA in 2019", López-Alegría said, and the organization is Axiom's *"gateway to the ISS"*. Three Axiom missions have flown so far, in 2022, 2023 and 2024, and the fourth one *"is going to happen within the next month or so"*.

In the spirit of *"expanding access to a lot of entities, nations and individuals" are being part of the crews, which so far "represent 11 different nationalities"*. In the upcoming Ax-4 mission, together with the commander Peggy Whitson, who has spent "more time in space than any American so far", astronauts from India, Hungary and Poland will participate, making it *"the second flight (in 40 years) for each of those countries and obviously the first to the International Space Station"*. Thanks to this initiative, researchers who would not have access to the ISS can perform their experiments. Ax–4 mission *"is going to do 60 science activities, which is by far a record, representing 31 countries"*. For the participating countries, *"it brings a lot of prestige, it's a great source of inspiration to the youth, and it is a chance to perform its own organic science investigations in the orbital laboratory"*. In the case of India, the additional value is the practice for the Gaganyaan missions. Another objective is preparing the team and procedures for when the Axiom Space Station will be launched.

So far, all the Axiom missions *"have a similar profile"*. The first thing is team building because the astronauts virtually did not know each other before. It is crucial because that's the way in which the crew members *"can bond with each other and discover each other's strengths and weaknesses"*. What follows are the trainings with NASA and SpaceX focused on living and working at the ISS and Crew Dragon, parabolic flights to experience microgravity, simulations with microgravity and preparation for emergencies. Training typically lasts 10 months and is followed by 2 weeks of quarantine, leading to the launch day, when the astronauts travel *"28.000 kilometres per hour for 9 min"* to reach orbit and then spend around two weeks in the ISS.

The training standards are now the same for agency and commercial astronauts, but when the commercial space station is opened, Axiom plans to *"at least relax the medical standards"*. It will be possible, López-Alegría explained, because having an astronaut is a significant investment for the agencies. Hence, the goal is for them to *"serve a long career, flying multiple flights over many years, maybe even decades"*, which is not the case for the commercial astronaut, as they might be nominated to perform a single experiment, he added.

All of this is done in the spirit of *"broadening the range of people who are able to fly today"*. An example is the experiment planned for Ax-4 that will "potentially open the door to type 2 diabetics".

It is a great time to be involved with space. It is genuinely, probably since the Apollo era, the most exciting time with this transition from just pure government to a mix of government and private uh space activity. Axiom *"is very proud to be at the forefront of all of that"*, López-Alegría concluded, at it would be hard not to agree with somebody whose experience ranges from flying on Soyuz and Crew Dragon, a difference of which he humoristically compared to driving a Lada and a Tesla.

> "Ax–4 mission is going to do 60 science activities, which is by far a record, representing 31 countries."

Expanding Access to the Indian Space Sector: International Outlook

Dr. Vinod Kumar, Director at IN-SPACe (Indian National Space Promotion & Authorization Centre (IN-SPACe), focused his GNF Session on India's global collaboration and space ecosystem building in the country. He reflected on the progress from India's humble beginning in 1963 to the current impressive achievements and state-of-the-art facilities.

Dr Kumar divided the history of the space endeavour into four parts: astronomical observations, the race to space with its culmination of the Apollo 11 Moon landing, global cooperation and space application with the ISS as an outcome and, finally, *"a paradigm shift for the space"* to commercialization stage. For India, that last phase started in 2020 with the *"space sector reform and space promotion"*, bringing IN-SPACe to life, allowing private *"companies to carry out end-to-end activities"* in the space sector. Additionally, NewSpace India Limited became known as a *"commercial wing of ISRO"*. The quadruple role of being a *"promoter, enabler, authorizer and supervisor is to take the space economy from around 2% to around 8 to 10% in the next decade"*, Kumar explained. The new policy also allowed support to start-ups and made the FDI (foreign direct investment) *"much more lucrative"*. This new approach has been already successful, he continued, as multiple private companies, start-ups, and VCs have profited and entered the space sector. India's government has also decided to attract young people to the sector and created special courses and *"a space-tech curriculum"* to prepare new generations for this *"paradigm shift"*. Another project involves the creation of seven *"Centres of Excellence in each region of the country"*, which will be *"available for private companies to scout academic students"* and invite them to work with them. Beyond domestic efforts, Kumar continued to say *"international outreach is now a very important activity. ISRO has demonstrated that we are pioneers in developing indigenous technology in a full spectrum of space activities. We are cost-effective, we are a well-known and high-quality nation that has a strong adherence to global standards"*, he said proudly, as India is working on promoting *"global collaboration and capacity building"*. As for international cooperation, India has divided its outreach to the *"Indian Ocean Region, global developing and space fairing nations and global, mature nations"*, for all of which *"all areas for collaboration are available"*, providing it will be beneficial for both parties involved. *"We have 290 plus cooperative agreements with 60 plus countries"*, Kumar specified, highlighting the cooperation with Italy and Australian companies especially.

"In India, in any form, we are here to help you", Kumar finished, inviting everybody to take advantage of these recent changes and policy relaxation.

India's Space Exploration Endeavour: International Perspectives and Opportunities

The last IAF GNF session of the second day of GLEX 2025 kicked off with the keynote regarding the technical aspects and objectives of the joint JAXA-ISRO planned mission of LUPEX/Chandrayaan-5, delivered by Dai Asoh, Project Manager for the Lunar Polar Exploration (LUPEX) Project Team at Japan Aerospace Exploration Agency (JAXA).

Asoh explained the importance of in situ resource utilization as one of *"the key technologies for expanding humans' activity and presence in the solar system or outer space*". With hydrogen being *"a potential resource on the Moon"*, more research is needed about "water ice quantity and quality" to determine its *"usage as an energy source"*. LUPEX/Chandrayaan-5's main objective is *"to obtain and investigate the ground truth data"*, Asoh continued. To achieve that goal, the mission must demonstrate *"the technology for staying the night on the Moon and excavating the ground"*. In addition to JAXA and ISRO involvement, NASA and ESA will provide some mission instruments. After landing near the Moon's South Pole, the LUPEX rover will travel a distance of around 1km, *"charge its batteries at the top of the hill and then go down to the crater or some lower portion of the lunar surface, perform observation of water ice using round penetration radar which ISRO developed"*. When the area with the potential existence of water ice is found, the drilling and sample acquisition will follow. The acquired sample will be heated to 500 degrees Kelvin (circa 227 Celsius), and the data regarding the quality and quantity of water ice will be obtained, Asoh stated matter-of-factly. This extraordinary mission is predicated no earlier than 2028.

The following part of the session was moderated by Pieter van Beekhuizen, Chairman of the Netherlands Space Society (NVR), who reflected on the *"inspirational speech"* of India's Prime Minister Narendra Modi during the Opening Ceremony and India's space journey. His question about the ISRO path to success was directed towards A. Rajarajan, Distinguished Scientist and Director of Satish Dhawan Space Centre, Indian Space Research Organization (ISRO). *"India, during 60 years of the existence of the space program, moved from the humble beginning of Nike-Apache launch"* to today's pinpoint landing near the South Pole of the Moon, Rajarajan reminded. What made this success possible was *"having a step-by-step program with incremental steps in each technology"* from the very beginning, which, thanks to the guidelines of Vikram Sarabhai, father of India's space program, has *"applications oriented towards the benefit of society"* as the primary and leading goal. The same vision underlines India's current achievements, with their planned culmination of *"Indian [human crew] landing on the lunar surface by 2040"*. It was not always easy, and included a lot of learning, also from the mistakes and failures, *"giving a lot of impetus to developing our own, indigenous capabilities, along with some collaborations"*, he continued. "Only after we had certain maturity did we look at the exploration" with the Chandrayaan program, the Mars orbiter mission, the planned Venus orbiter mission, and the space station project. *"As we develop, we also improve our application areas so that they go hand in hand and the entire space society is able to benefit from these developments"*, Rajarajan summarized. When asked about the importance of the ISRO cooperation with Axiom, as the Indian astronaut Shubhanshu Shukla is about to be the first Gaganyatri in the ISS, and as India is planning to have its own Bharatiya Antariksh Station, Rajarajan highlighted the importance of its effect on *"understanding the human space mission activities and the human space experiences in a space station"*. Equally important are the experiments he will carry out while in space, with priority given to *"microgravity experiments and research"*.

Michael López-Alegría, Chief of the Astronaut Office and Ax-1& Ax-3 Missions Commander at Axiom Space, elaborated on the topic of the commercial astronauts' flights and the experiments planned for Shubhanshu Shukla during the Ax-4 mission. "The majority of what we do on a private astronaut mission is very similar to what NASA, ESA, CSA, or JAXA missions would look like, which is scientific research and a bit of outreach back to the native countries", he clarified. While some experiments are performed jointly by the mission's astronauts, the Indian portion during the upcoming light will include

> "A lot has been said about how to collaborate on a government-to-government level, but there are so many tangible ways to collaborate globally."

investigations labelled 'sprout' (which will focus on growing plants in microgravity) and 'muscle' (with a focal point of muscle dysfunction in the orbit and its causes, which can later we applied also to the muscle malfunctions and disease on Earth). As Axiom is also preparing its own (commercial) space station, López-Alegría highlighted its most important features: *"scalability and adaptability"*. In contrast to ISS, he continued, *"it doesn't really have a finite end. We plan to be able to continue to add modules or change modules as the needs see fit, and that is going to depend on the customer"*. The first module will be initially attached to the ISS no earlier than 2027. Following, the independent module HAB 1 will be launched and docked with the first part, creating a fully *"functioning station with everything needed to have up to four crew members on board and some research capability"*. In parallel to the modern space station, Axiom is also developing a new generation of space suits, which will significantly improve mobility and allow maintenance to be carried out in space without the necessity of bringing them back to Earth.

With Shukla, an ESA reserve astronaut, Sławosz Uznański-Wiśniewski will be a crew member at Ax-4 mission, making him the second Polish astronaut in space and the first to go to ISS. Reflecting on ESA-ISRO cooperation, Daniel Neuenschwander, Director of Human and Robotic Exploration Programmes at the European Space Agency (ESA), first expressed his recognition of India *"as it marries political leadership and vision, and space capabilities. This is inspiring"*, he said. While ESA supports Poland for Uznański-Wiśniewski's Ignis mission, ESA wants to start with *"building up cooperation [with ISRO] with short-term low-hanging fruits"*, which hopefully later will *"evolve to midterm and longer term"*. The fact that the Indian astronaut will also perform experiments for ESA *"shows this required cooperation independent from where the astronaut ultimately comes from, and this applies, of course, to the other crew members"*, Neuenschwander added. The plan for further cooperation with ISRO has been highlighted by the freshly signed joint statement, which *"allows us exactly to build this bridge towards long-term collaboration"*. Meanwhile, ESA is preparing for its ministerial conference in November 2025 to *"promote the idea of decreasing dependencies because the less dependent you are on some projects, the more robust you will be in cooperation afterwards"*, he clarified. As cooperation is essential for space exploration, a statement all panelists agreed with, ESA is thinking not only about big-scale projects but also *"elements like outfitting a station a state-of-the-art station"* and utilizing Europe's experience on life support systems and human space flights.

Jill Smyth, Director for Space Exploration Planning, Coordination and Advanced Concepts at the Canadian Space Agency (CSA), also found India's journey exemplary. Referring to the lunar landing in 2023, she said that *"the level of transparency that India had has inspired the youth in India. I would go further than that - it was really an inspiration globally. I think that it is bold and exceptional leadership to have shared it with the whole world"*. She focused on explaining how the agency in Canada operates under

the Ministry of Industry, Science and Innovation, which translates to the fact that in *"everything we do, the goals are to advance science, spur innovation, create economic benefits, and bring benefits to the Canadian population"*. Currently, Canada's focus, among others, is lunar exploration, with investments *"in technology demonstration and technological advancements"*. Canada's strength is the niche capability of robotics, highlighted by the advanced works on Canadarm3 and mobility with the lunar rovers. While the works developed, Canada is *"keeping a close eye on what's going on with the NASA budget"*, but, as Smyth underlined, it will not affect its dedication to the projects. As CSA is a national agency funded with taxpayers' money from Canada, *"we need to reinvest a large proportion into Canadian companies. A lot has been said about how to collaborate on a government-to-government level, but there are so many tangible ways to collaborate globally"*, she continued, referring to the *"extreme transformation that the private sector of India"* is under, which *"is a good opportunity to try to seek how we can have our industries working together"*, Smyth added. While talking about standards and interoperability as still crucial, *"we need to think about new ways to collaborate and integrate other voices"* into the vast topic of lunar exploration. Another new way to collaborate, Smyth explained, is the planned *"proposal to explore science payloads that could go on our lunar utility vehicle"*, with RFP open internationally. Canada is also using its *"mining terrestrial applications that we need to tap into for space exploration"*, bringing back benefits to the Earth. CSA and the Canadian Department of Industry, Science and Economic Development work together in the initiative called Moonshot 4 Mining, Manufacturing and Minerals, in which a *"mining company would team up with a space company and work together to address a challenge that they might have or that they would identify"*, a step towards having more and more of this kind of business inclusion initiatives.

With many audience questions addressed in the responses of the speakers, the second day of the GLEX 2025 conference came to an end with the leitmotiv of space exploration's need for cooperation. And, as A. Rajarajan stated, *"there is no doubt about that"*.

International Astronauts Session: Life Between Worlds – The Astronauts' Experience

This vibrant panel with renowned astronauts from around the world, allowed sharing insights into their journeys, experiences, and visions for space exploration. The IAF GNF session, moderated by Christian Feichtinger, IAF Executive Director, highlighted the significance of space missions in inspiring nations, advancing technology, and fostering international collaboration.

Rakesh Sharma, the first Indian Astronaut who flew in 1984, *"with his mission marked a milestone in India's conquest of space"*, as the session moderator mentioned. Even though Sharma's mission happened 40 years ago, his presence as a *"veteran and hero here in India makes people frantic when they see you"*, the IAF Executive Director observed. Sharma reflected on the *"impact of his spaceflight on Indian society and collective imagination"*, and he added that he *"must confess that I was not very well prepared for what to expect after the space flight. The kind of impact space flight itself had on our fellow citizens was an eye-opener"*, especially as his achievement *"was streamed live in every living room"*, making an impression of "science fiction come alive because, till then, it was something out of this world". Not wanting to label his achievement in terms of legacy, Sharma highlighted the 40-year gap between India's crewed flight, saying that people in India are ready for *"Angad and his colleagues, the next lot of Indian astronauts"*, Sharma stated humbly, as well as the upcoming missions to Moon and Mars.

Also, the 'firsts' for their countries were Hazza Al Mansoori and Alper Gezeravcı.

Hazzaa Al Mansoori, the first Emirati astronaut of Mohammed Bin Rashid Space Centre (MBRSC), after spending eight days on the ISS in 2019, became *"a national hero and a symbol of the UAE's growing ambition for space exploration"*. He stated that human space flight is something out of this world in terms of its impact on humans and generations to follow. *"It felt like the Apollo era for us"*, he continued, admitting that it was *"a big responsibility to share all with everyone on the ground"*. Referring to the meeting with schoolchildren from India later on, he mentioned being slightly surprised to be recognized. Still, it also made him extremely grateful, as the children, upon seeing an astronaut, *"felt that this person did not belong to one country. He belongs to everyone"*.

Alper Gezeravcı, First Turkish Astronaut, Turkish Space Agency (TUA) Board Member, Turkish Space Command Coordination & Execution Director F-16 & KC-135R Pilot, flew to the ISS in 2024 with the Axiom-3 mission, *"marking a milestone in Turkish space exploration"*. He emphasized the challenges faced by Türkiye, as the announcement of his groundbreaking space mission coincided with a devastating earthquake. *"And when you experience this kind*

> “Instead of creating another far-off hell I think we should start by recreating heaven which we already are a part of, and we, I think, are busily destroying.”

of disaster, you are going back to the Maslow triangle, and nobody cares about your ideals or dreams to inspire the next generations”. The government was faced with the very hard decision of keeping the inspirational mission while many people were suffering, supporting its continuation by stating *“that if you focus only on today’s difficulties, then we would be stealing from the dreams of the next generations”*. Gezeravcı also expressed his appreciation to Axiom for the support as well. Despite hardships, the mission symbolized hope, inspiring over 350 outreach events across the country emphasizing that space exploration fuels national pride and future aspirations. These efforts will continue because *“until we make this unusual field of practice up in the space, [let’s] make it usual in every mind of our children”*.

Sirisha Bandla, Astronaut and Vice President of Government Affairs for Virgin Galactic, who “became the second woman of Indian origin in space when she flew on Virgin Galactic’s Unity 22 mission in 2021” and who delivered an inspirational speech the previous day, offered advice to aspiring astronauts: *“Find your passion, give it your all, stay committed, and remember that it’s okay to be the first but make sure you’re not the last.”* The last part of that advice reflects on the importance of equality, *“as we just passed 100 women in space last year, which is incredible to think about”*, as it encourages women not only to become astronauts but also to pursue other STEM fields careers. What we should always keep in mind, Bandla continued, is that “sometimes it is easy to inspire, but the hard work comes after in creating an environment where people feel like they belong”.

Michael López-Alegría, Astronaut, Chief of the Astronaut Office and Ax-1 and Ax-3 Mission Commander at Axiom Space, is also a *“veteran NASA astronaut and record-holding spacewalker”*. Michael now leads commercial space missions with Axiom Space and commanded the first-ever all-private crew to the ISS in 2022. Also worth mentioning is that López-Alegría *“is a strong supporter of the International Astronautical Federation and is present at every event organized by IAF”*, mentioned Feichtinger. As Axiom Astronaut has a lot of experience in training first-time space fliers, he said that the training, no matter the type of the mission, *“is a very solid system that takes care of all the advice. Still, I can offer some titbits about how to prepare for what your body is going to feel like when you first get into microgravity”*, he added. The most important advice, however, that anybody can be given is *“to enjoy yourself”*, which is not as easy as it may seem because there is always a lot of work to be done, and *“it is hard to take a moment to inhale and just absorb what’s happening when you’re not really conscious about that”*. This difficulty reaches an even higher level during the EVA, as the precision of the task given takes nearly all the time.

Eytan Stibbe, Israel’s second Astronaut, flew on the Axiom-1 mission in 2022, which was commanded by Michael, promoting science and education through the Rakia mission during his 17 days stay day on the ISS, added to the conversation his thoughts about fear being an important factor for the astronauts, solution for which is, he said jokingly, *“to go with Mike as he is so confident and he gives you all this confidence”*. However, *“the biggest fear during the waiting moments before launch is that it is cancelled”*, Stibbe elaborated. It is not difficult to understand, as the amount of work and preparation put into every mission is tremendous. Another observation that the Israeli Astronaut wanted to share is that *“the launch was much smoother than expected”*, especially as the expectations are vastly formed based on the movie scenes. Stibbe’s career in space also started *“at a low point because our first Astronaut did not survive, so the sentiment in Israel was negative for human space flight. Consequently, the government was not promoting new astronauts”*. In such a scenario, the commercial mission came as a solution to the issue because *“the government could join (which it did, offering many experiments and scientific activities) but not lead”*. Private missions are also more flexible, and *“you decide what you want to do”*, which allowed Stibbe to do a performance art while in space, which is “something that no government astronaut has the privilege to do” and which turned out to be one “*of the top experiences in space, actually”*.

Angad Pratap, an Indian Astronaut Group Captain, as an accomplished test pilot with the Indian Air Force, is one of the astronauts designated for the Gaganyaan mission, representing a new generation of Indian space pioneers preparing for the country’s first crewed space mission. He expressed pride in India’s multi-faceted space approach involving lunar, orbital, and human spaceflight programs. He highlighted the *“collaborative spirit and the technological advancements”* that prepared India for its first crewed mission. Everything that ISRO has achieved so far *“is a big thing in itself, and it talks deeply about the kind of commitment the country is making”*. Moreover, as was already stated many times, *“India is not about being the first, but whatever we learn and achieve in this journey, we want to share it with the world”*. ISRO’s achievements are even more impressive once we realize that many initiatives are being developed in parallel. On top of the human cred flight, India has also been working on successful docking experiments, Bharatiya

Antariksh Station, *"the capability to go to the Moon and come back to the Moon and the next generation launch vehicle, with the same set of people*" working on all of them. Being an astronaut is a different thing altogether, Pratap added.

Gopichand Thotakura, an entrepreneur and pilot, became the second Indian-born space traveller who flew on Blue Origin's New Shepard-25 mission. Reflecting on the first International Astronautical Federation event he attended and the possibilities it offers, he mentioned that *"India is a country with a lot of people, schools and universities",* many of which he has the privilege of visiting. Even though not all of them want to be scientists or astronauts, they're *"very passionate about the little things in life. It's not just going to space, but all other portions that contribute to that"*, often more important *"than the actual person going to space and coming back"*. The issue is also that those people who made it possible for an astronaut to be in the rocket are, *"more often than you would know, not recognized for what they have done"*. There are people with huge and important dreams whose goal is not to be astronauts but, for example, to make *"a satellite box accessible to every country so that it can be taken to space. I think that's very important"*, Thotakura said.

The initial statements were followed by questions from the audience, which, unsurprisingly, were plentiful. López-Alegría asked about the difference between NASA and Axion missions and admitted that there are many similarities, but private missions can be more flexible and more customer-focused. Angad Pratap elaborated on what inspired him to become an astronaut. The first stimulus was other astronauts and their achievements, strengthened by the *"outside feeling that as a commoner, I would have two or three things that I would be able to do. One of them was to become a very, very humble human being and represent all humanity"*. The second one consisted of *"developing myself and my capabilities and my knowledge in multiple fields and learning a lot about teamwork with no discrimination of any kind. In the end, I will feel more human"*. The following question was about the psychological challenges which await astronauts. Eytan Stibbe mentioned that one of the biggest trials is "preparation for failure", as there are a lot of different expectations, *"and your chances of succeeding in satisfying them all are very low"*. Rakesh Sharma added to the discussion, reminding us about experiencing the *"so-called overview effect"* - seeing Earth as a fragile entity *"with the degradation which is going on"*. His experience of seeing the spreading fires made him aware that pollution *"really is no respecter of boundaries"* and that protecting our *"life-giving environment"* is in the crucial interest of everyone. This is an essential lesson for future exploration and our species' expansion – *"instead of creating another far-off hell, I think we should start by recreating heaven, which we already are a part of. We, I think, are busily destroying it"*. Sirisha Bandla said that one issue she was not prepared for was *"this mindset that space flight is not your peak. It's a platform to go on and do other things"*, which meant that she *"learned the hard way afterwards"*.

As the experience that provided the highest level of discomfort, Hazzaa Al Mansoori identified the *"coming back from space and re-entry"* and compared it, using his commander's words, to being on a roller coaster. *"Expecting the unexpected is what you need to be prepared for, and that's what they don't teach you in training"*, reflected Gopichand Thotakura, also mentioning the importance of *"having fun because if you forget to have fun, I don't think you'll remember the best moments"*. Alper Gezeravcı's perspective was underlined by the fact that *"what might be taken as a discomfort in many minds is actually the nature of our lifestyles and backgrounds"*. This quality is exactly what allows you to enjoy it, he highlighted. *"Whatever a playground for a child is, the space is the same for an astronaut"*, Gezeravcı summarized. Eytan Stibbe's post-flight reflection was that his business was thriving without him, so he *"continued getting more and more involved with the Rakia team, developing this outreach potential of using space as a tool to attract and inspire next generations and research and philosophical thought groups"*. The following questions circled around the topic of robotics and AI, with future prospects pointing toward more autonomous, AI-driven systems to assist astronauts, the difference in the training with the Russian being more theoretical, fundamental understanding, while the American is more practical, simulation-based, with private companies like SpaceX favouring *"hands-on, computer-based training"* and Blue Origin's future focus more on psychological requirements and training, as the technology will take over the more technical parts of the space flights.

The session concluded with a lightning round where panellists envisioned the future of space exploration as *"bright," "exciting," and "collaborative."* The overarching message was that space is a universal frontier - a domain where technology, diversity, and international cooperation will shape humanity's next chapter. The panellists' stories and insights serve as a powerful reminder that every contribution matters and that the journey into space is a collective effort driven by curiosity, resilience, and hope.

ILOA-ILEWG Galaxy Forum "International NewSpace to the Moon"

The IAF GNF session encapsulated a discussion on lunar exploration, featuring experts from diverse backgrounds—space scientists, legal scholars, industry leaders, and policymakers. The dialogue covered the current landscape, technological advancements, legal frameworks, international cooperation, scientific opportunities, and public engagement related to lunar missions. The panellists emphasized the transformative potential of lunar exploration in the 21st century, highlighting collaborative efforts, innovative technologies, and the importance of public support for sustainable space endeavours.

The session began with an engaging icebreaker initiated by Jatan Mehta, Space Writer, Author of Moon Monday and panel moderator: who will land humans on the Moon first this decade? The consensus leans toward both the US and China achieving lunar landings around 2027–2028, with a possibility of near-simultaneous missions, while the audience voted for China.

Steve Durst, Director and Founder of the International Lunar Observatory Association (ILOA), based in Hawaii. ILOA's mission *"is to expand human understanding of the cosmos through observation from the Moon"*. The ILO-1 flagship mission's main objectives "are the first image of the Milky Way galaxy ever from the lunar surface in this century robotically, astronomical observation, Hawaii's 21st Century Astrophysics and Lunar commercial communications". ILO-1 is to be launched in 2027 and was proceeded by the precursor mission of ILO-X (in cooperation with Intuitive Machines), which was the first lander by the USA in over 50 years. Another undertaking, ILO-C, scheduled for 2026, is to be a part of the Chinese Chang'E 7 mission. *"Here we are in 2025, one-quarter of the way through this pivotal 21st century – a great time to take stock, look ahead, be ambitious, and be optimistic about what we humans can do in the next 75 years with our resources and wise application of our ideals. I really believe that human destiny in the 21st century will be decided in the Jupiter and Saturn systems, where 90% of the solar system planetary mass is located"*, he said futuristically.

> "I really believe that the human destiny in the 21st century will be decided in the Jupiter and Saturn systems, where 90% of the solar system planetary mass is located."

Pascale Ehrenfreund, President of the Committee of Space Research (COSPAR) and Research Professor of Space Policy and International Affairs at the Space Policy Institute/ George Washington University in Washington DC, advocated for sustainable and responsible space exploration, even more essential now, as over 150 lunar and cis-lunar missions are planned, in the next decade involving multiple countries and commercial entities. She also elaborated on COSPAR's cooperation with UN COPUOS (United Nations Committee on the Peaceful Uses of Outer Space) on planetary protection, space debris, environmental databases, and other regulatory frameworks. Another vital collaborator of COSPAR on the topic of *"sustainable measurements on sustainability for space exploration activities"* is the World Economic Forum. The work emphasized the need for comprehensive environmental data and international cooperation. *"We have to incorporate scientific research into policies continuously"*, harmonize regulations, and ensure transparency, interoperability and public awareness with the aim of managing environmental impacts.

"Fasten your seatbelt! We are going to the Moon all together", began Bernard H. Foing, Executive Director of the International Lunar Exploration Working Group (ILEWG), EuroMarsMoon initiative. The Group believes that new technology, new AI, machine learning applied to data analysis, miniaturization of instruments and cooperative robotics are needed to achieve the new space. *"We also do new space in terms of we managed to get money"*, he highlighted. The financing comes from commercial partners, grants from the European Union, space agencies and universities. What follows is the equipment testing in the places that might imitate the conditions on the Moon or Mars. *"There is also a special training academy for our researchers, astronauts and business people"*, Foing added. Yet another initiative is the Space for Peace. Starting in 2010, the Group got into commercial lunar exploration, building commercial landers and rovers, as well as received funding from the European Commission to train space entrepreneurs, creating a new curriculum to train the next generation of space explorers in science and technology in humanities social sciences and in management and business. One of the latest projects is a collaboration with Space Renaissance International Foundation (with a celebration coming in June with a payload with a gallery of scientific samples, artworks and logos of 40 organizations, including IAF) *"to develop also all the humanistic aspects of going to space and the proposal of having the 18th SDG dedicated to space for all on Earth and beyond"*, Foing concluded.

Referring to the presentation of her fellow panellist, Tanja Masson-Zwaan, Assistant Professor and Deputy Director of the International Institute of Air and Space Law at Leiden University and President Emerita of the International Institute of Space Law (IISL), joked that as a space lawyer, *"I don't have any cool pictures to share. I can only show you the United Nations treaties booklet"*. Today, space law is not as exotic as it was at the beginning of her career, Masson-Zwaan mentioned. She underscored the importance of legal frameworks governing lunar and other extra celestial bodies activities. The Moon, as the only celestial body humans have stepped on, *"is singled out among those international legal instruments"*. With a surge of space activities and the emergence of commercial companies, the regulations are understood not *"in the sense of stifling or bothering with rules but also facilitating ambitious plans"*, which are even more essential. There are still many unanswered questions. *"Do we want a Coca-Cola billboard on the Moon?"*, she asked rhetorically. The huge challenge is that the existing regulations apply to the states, and *"the big issue will be how to make sure that those private entities are also part of that"* regulatory ecosystem. The importance of the issue is reflected in the growing interest of the young generation in space regulatory law. Also essential are *"interdisciplinary approaches. We should not all be on our island, on our silo, but we have to consider all these aspects of space exploration, including the legal ones"*, she summarized.

Gaurav Seth, Co-founder and Chief Executive Officer of Piersight Space, *"a new space startup building Earth observation satellites for persistent ocean monitoring using synthetic aperture radar and AIS sensors"*, used to be a part of ISRO's Chandrayaan-2 mission and the proposal for the

LUPEX mission. These priceless experiences *"of building planetary science payloads have significantly inspired the designs of our company"*, and ISRO informed his perspective on technological innovation, miniaturization, and international collaboration in lunar and planetary missions.

The panel also discussed how payload deployment has transformed from the Apollo and Soviet era to today's commercial and international missions. Durst recounted his experience with payloads on US and Chinese landers, emphasizing public-private partnerships and international collaborations, which for him started with the NASA Eclipse program. Highlighting the changes and plenitude of opportunities nowadays, Durst highlighted that ILOA is also *"developing a dynamic partnership with Thailand, which is exemplary for astronomy"*.

Focusing on the public-private dichotomy in space science missions and the commercial potential of vastly enlarging the number of experiments and research carried out, and, at the same time, their challenges, Ehrenfreund started with the positive side of *"being a boost for science"*, with the lower cost being the most significant enabler. Foing praised the fundamental research done by the space agencies, which must be continued. However, *"now we also have the opportunity to go to the next step, and it will be partly for science but also for developing technology"*. He added that "we have to learn we can also do science from the Moon".

Continuing the theme of changing paradigms for space exploration, Masson-Zwaan focused on the UN's role in coordination and regulations, including the principles of resource utilization. *"In space law, the system is really built on supervision by states"*, which entitles responsibility for *"national activities, including activities by private entities"*, as well as liability for damages caused by either, she explained. "The question of oversight is extremely important in the sense of supervising" those national activities, she added. As states and their ambitions and objectives differ, the space law, rooted in the Outer Space Treaty, *"we do not have a guarantee that these regulations governing the private companies will be harmonized, and that is why I think the role of the United Nations is essential"*, Masson-Zwaan stated.

Elaborating on the experience of creating a *"very elegant radar system, mapping water ice on the Moon Poles and being involved in landing site selection for Chandrayaan-2"*, Seth selected calibration of the instrument as the biggest challenge, especially "the lack of calibration targets on the Moon", which force the team to come up with a *"unique strategy of ground-based characterization, where a lot of calibration was smartly done on the ground"*. Agreeing with Seth, Foing added that we must *"develop some standards for communication for navigation positioning, and for this, there are a lot of opportunities for commercial service to be involved"*.

The next question was directed mainly to the Europeans in the panel and focused on Europe's capabilities and challenges due to the budget cuts in the USA. The experts highlighted the need for independent human spaceflight and filling in the technological gaps. Foing reflected on past successful missions executed in a short time, which translates to the fact that there is technical capability in Europe. Nowadays, *"having a big vision for Europe is not enough because a vision without execution is a hallucination"*, he claimed.

The more controversial topic evolved around Durst's question: *"on Earth, we have private property, so how would that translate or be on the Moon"?* While he admitted that in the Western perspective, *"independent enterprise and private property are enshrined fairly high"*, Masson-Zwaan retaliated by saying that one could own a house on the Moon. It's *"just that you cannot own the Moon because no one is the boss of the celestial body as such"*. Foing added that according to the laws, there are no wars, borders, or weapons permitted on the Moon, and he would opt to keep these advantages.

The panel painted an optimistic yet pragmatic picture of lunar exploration's future. The next decade promises unprecedented activity driven by technological innovation, international cooperation, and public engagement. The collective goal is to explore responsibly, advance science, and inspire humanity, making the Moon a shared heritage and stepping stone for humanity's interplanetary future.

This comprehensive discussion underscored that lunar exploration is not merely a race but a collaborative journey that requires scientific rigour, legal clarity, technological innovation, and public support. As nations and private entities chart their paths, international frameworks and sustainable practices will ensure that the Moon remains a beneficial and peaceful domain for future generations.

> "Now we have also the opportunities of going to the next step, and it will be partly for science, but also it will be for developing technology."

The Governance of Space Exploration

The IAF GNF session marked a historic milestone in the realm of space governance, being possibly the first to focus exclusively on the governance of space activities at an International Astronautical Federation (IAF) event, observed Tanja Masson-Zwaan, Assistant Professor and Deputy Director of the International Institute of Air and Space Law at Leiden University and President Emerita of the International Institute of Space Law (IISL) and the session moderator.

The discussion underscored the evolution of space law from a niche academic subject to a critical component of global policy, regulation, and international cooperation and its multifaceted challenges and opportunities shaping the future of space governance in a broader context of space exploration, commercialization, and geopolitics.

Historically, space law has been intertwined with the activities of the International Astronautical Federation since its inception in the 1960s, notably through the creation of the International Institute of Space Law (IISL). The discussion focused, however, on the dynamic landscape of space governance, the role of international treaties, national policies, emerging actors, and the evolving legal frameworks necessary to ensure sustainable, safe, and equitable space activities.

The session started with a reminder of the Pact for the Future, adopted by the UN last September with its 56 actions, the last being: *"We will strengthen international cooperation for the exploration and use of outer space for peaceful purposes and the benefit of all humanity. We reaffirm the importance of the widest possible adherence to and full compliance with the 1967 Outer Space Treaty"*, emphasizing three topics: space traffic, space debris and space resources.

Ranjana Kaul, Partner at Dua Associates in New Delhi, explained the latest development in India's progressive approach to space policy (highlighting also the differences between the concepts of law and policy) on long-term sustainability. *"We are still awaiting a similar set of technical regulations for launch vehicles, and when that is built up, then we will truly be in a position to have a space law"*, she explained. This policy is the reflection of the space sector reforms in India, which included commercial activities. It is the *"first time that India has ever articulated a national policy pertaining to space"*. The portion regarding the space resources and their utilization is *"a gradual buildup and progression"* based on India's lunar exploration with its Chandrayaan missions. Kaul stressed the fact that *"a policy, by its very nature, is an evolving document"* and will be adapted according to new developments. The new policy also applies to the private sector. The Indian Space Promotion and Authorization Centre (INSPACe), a startup-like body fostering industry growth and interaction with the government, *"has actually hit the ground running, providing a very interactive relationship between our commercial companies, the new companies and also our established commercial companies that have been suppliers through the government procurement route for India's space program"*. Together with INSPACe, two other entities were created: the Indian Space Association (ISpA) and Satellite Industry Association (SIA-India), which work very closely with INSPACe, creating *"a tremendous synergy of these three institutions that is really feeding our system"*. Kaul also reflected on the new Initial draft set of recommended principles for space resource activities presented by UNOOSA, which happened nearly in parallel with GLEX 2025. *"I have to say I am terribly impressed with the outcome, as it was very well put together and was done in record time"*. What Kaul found the most significant is the last of proposed principles, namely the review of principles, also mentioning that *"conflict on the Moon is not an option, as much as there is conflict on our Earth"*.

Luxembourg's pioneering role in issuing the world's first license for a space resource company (iSpace Europe) was stressed by Bob Lamboray, Senior Manager for Lead Exploration and Space Resources at the Luxembourg Space Agency (LSA), and Strategic Advisor for the European Space Resources Innovation Centre (ESRIC). *"The country has a dedicated space resource law since 2017. In 2020, iSpace won the NASA contract for the collection and transfer of ownership*

of regolith on the lunar surface, which was not a sample return mission per se but rather an exercise in understanding how to execute a commercial transaction between two entities on the lunar", said Lamboray, clarifying the scope of the before mentioned license. While these kinds of authorizations are still learning in process, Luxembourg's government and space agency aims to enable industry without limiting innovation while ensuring responsible, safe operations, exemplifying a modern, facilitative governance model. *"For Luxembourg, space is seen as a way of diversifying the industry and the economy"*. Being a small country, *"we simply do not have the means to do our own missions, so I think we see these commercial opportunities as a way to drive and grow this sector beyond the public funding, with a goal of creating a sustainable space economy in Luxembourg"*. As it was the first step in the direction of authorization of space endeavours, there are a lot of questions still left unanswered, especially regarding the more complex projects, such as fully commercial space stations. But the initial stage is always to *"understand the nature of the activity, make sure that there's a clear commercial driver that is non-military, that's responsible and safe, and that companies have the financial and technical means to operate in a professional way"*, with finding the right balance *"between overregulation and nonregulation"*, Lamboray stated.

As China has launched the initiative of the International Lunar Research Station (ILRS), Wang Zhongmin, the Director of the International Cooperation Center, Deep Space Exploration Laboratory (DSEL), clarified the issues connected with the international collaboration and *"concurrence or divergence with the Artemis principles"*. The project, led by the Chinese National Space Agency, has as its goal the establishment of a permanent, international lunar infrastructure for robotic exploration and future human habitation. As ILRS is a program, it isn't easy to compare it with the Artemis Accords, *"as we don't yet have such a soft law"*. Still, both aim for peaceful utilization, scientific research, and international cooperation. Wang stressed that China plans the open access to collaboration on the ILRS from any country around the globe and that within the ILRS initiative, *"everything [is done] under the legal firm of the UN COPUOS, so we follow the outer space treaty to protect the environment"*. China will also share samples taken in the Chang'E 5 mission, an initiative for scientific studies, which will open again to any country in the world. *"This means that although we do not have Artemis Accords, we are following all of the international law"*. He also mentioned that after deeply studying the Artemis Accords, *"we still have an inner problem with the issue, but we think that we should have better lunar regulation, which could be accepted by all of the countries"*. However, it does not mean that countries that signed the Artemis Accords are not welcome to join the ILRS project. The same applies for the future Mars and Mars sample return missions – the open invitation will be extended to all, regardless of being a signatory of Artemios Accord or ILRS regulations, even though being a part of ILRS will grant additional benefits, such as more students' scholarships. Considering the long-term sustainability guidelines on the one hand and innovation promotion on the other, Wang mentioned that regulations can incentivize the development of environmentally friendly technologies.

> "Exploration and use of outer space shall be carried out for the benefit and in the interest of all countries, irrespective of their degree of economic or scientific development and shall be the province of all humankind."

Geetanjali Kamat, Manager of Legal & Policy at Digantara, focused on the principle that *"exploration and use of outer space shall be carried out for the benefit and in the interest of all countries, irrespective of their degree of economic or scientific development and shall be the province of all humankind"*. She started with the statement that today, *"major space fairing countries make huge leaps in technological advancements and innovations"* and are also leading the path for having a regulatory framework, guidelines, and policies in place. What must be highlighted is that such an *"approach should not be taken by just a handful of countries that have those capabilities"*. To achieve that aim, an international, open dialogue is crucial. There is also the issue of having *"national laws, policies, and frameworks to account for novel space activities"*, giving an example of Luxembourg as a case to be followed. She also agreed that the policies must be *"subject to a review mechanism"*, which, due to the speedy pace of the innovations, must be *"expedited or given regulatory clarity"*. At the same time, it is *"important to be realistic and a little bit more practical, given the current geopolitical context"*. With the currently existing treaties as *"a foundation of strong legal principles"*, the creation of the new treaties might be more complicated, as there are so many new entities whose opinions must be taken into consideration. Last but not least, young professionals and diverse participation are essential for inclusive, innovative policies, Kamat added.

This comprehensive overview underscored the critical importance of evolving governance frameworks to meet the challenges and harness the opportunities of the new space age. As the sector advances, continuous dialogue, international cooperation, and innovative legal solutions will be essential to secure a sustainable future for space activities.

Beyond Earth, Beyond Age: The Key Role of Youth for the Future of Space Exploration

The last IAF GNF Session of GLEX 2025 underscored the crucial role of youth in the ongoing and future endeavours of space exploration. Moderated by an enthusiastic host, Shrawani Shagun from the Space Generation Advisory Council (SGAC), the event brought together a distinguished panel of experts, visionaries, and young professionals to discuss how the energy, innovation, and perspectives of the younger generation are transforming the space industry. The overarching theme emphasizes that "youth are not just the future but also the present"*, actively contributing to scientific, technological, and policy advancements that will shape humanity's journey beyond Earth.*

Clay Mowry, President of the International Astronautical Federation (IAF), reminded the audience that the *"average age in the Apollo program was something like 25, 26 years old"*, and we are witnessing the same trend happening now, "particularly in the United States", given SpaceX as an example. This dynamism *"and the amount of investment that's flowing in makes the most exciting time right now in the space industry that I've been in in 32 years"*, Mowry highlighted. *"The students are the flywheel, the engine that basically creates and throws off all the other ideas and energy"*, which is also highlighted by the number of young people participating and submitting their abstracts to the International Astronautical Congress (IAC) every year. His advice for young people was to *"take the risk, take the job, step into the job, don't have impostor syndrome" and learn from every experience thrown at you. He also added: "we're proud of SGAC. We're proud of what you guys bring, and I think it's fantastic"*.

Reflecting on how being a part of SGAC can help with opening professional opportunities, Shreya Santra, Assistant Professor in the Department of Aerospace Engineering at Tohoku University and a volunteer at the SGAC, talked about her first IAC (International Astronautical Congress), which she attended in 2015 thanks to the scholarship, referring to it as a life-changing event, as she met people her age, who were *"doing incredible work and that was my inspiration"*. SGAC is "a permanent member of UN COPUOS and the IAF", provides mentorship, networking, and project opportunities, and facilitates participation in significant events like the International Space Conference (ISC) for young people ages 18-35. People who are over 35 (jokingly referred to as dinosaurs by the panellists) are invited to serve as mentors, emphasizing the fact that age is not a barrier to contributing and giving back to the community. It is a *"unique platform with over 30.000 members from more than 165 countries"*, making it one off *"the largest networks of space students and young professionals"*, Santra concluded. She also emphasized that all influential people have been young once, so you should "not be shy and just learn from your experiences with trial and error". Even though a lot of progress has been achieved in the last decade, there are still geographical gaps, financial constraints and a lack of awareness about opportunities and career pathways in space, especially for tier 2 and 3 cities, not to mention space emerging countries. *"Space is interdisciplinary and intergenerational, so it is very important that we all work toward that"*, she concluded.

Lisa Vitaris, Director of IAC Sydney 2025 at the Space Industry Association of Australia (SIAA), noticed, coming from a different industry herself, that it is *"really unique for the space sector to have such a thing as SGAC"*, as it unites *"amazing minds that come together to solve probably some of the world's most complex challenges"*. Vitaris also emphasized the need for cross-discipline, as we need, for example, *"more marketing and communications professionals to change the narrative about space on the public stage"* and

> "Space is driving the future. It is solving the most complex problems that we have on Earth. It is helping with climate change, improving agriculture it is helping to improve critical minerals, emergency services, bushfires and so on."

make it universally known how it changes our lives on Earth. As advice for young people, Vitaris suggested not to overlook leadership skills and promote yourself – *"and then those opportunities will come. There is no reason why they shouldn't"*. She also advised against perfection and a fear of failure, as failing is one of the best learning processes. Vitaris also pondered *"the unfortunate reality that many young people today struggle to make a living by working in the space sector"*, saying that she cannot fully comprehend it as *"space is driving the future. It is solving the most complex problems that we have on Earth. It is helping with climate change, improving agriculture it is helping to improve critical minerals, emergency services, bushfires and so on"*. To rectify this problem, the crucial step is, as she also mentioned earlier, a perception change and the spreading of the message of *"what space is actually useful for and why space matters"*. Its importance is reflected in the impact that the International Astronautical Congress (IAC) has *"because as soon as you host an IAC in your country, you are able to see growth and a spike in the space industry"*.

As a person who has *"championed the value of cross-generational collaborations"*, Pascale Ehrenfreund, President of the Committee of Space Research (COSPAR) and Research Professor of Space Policy and International Affairs at the Space Policy Institute/George Washington University in Washington DC emphasized the role of *"the institutional memory"* and the way in which experienced professionals guide and mentor young talent, ensuring knowledge transfer, while, at the same time, younger generation can challenge and question the status quo, fostering disruptive innovations. She also referred to the 3G Initiative of the International Astronautical Federation (IAF), *"which is actually doing that"* by building an inclusive environment in which professionals actively mentor young talent (and vice versa), and such a *"combination will bring us further into the future of space exploration"*, Ehrenfreund stated. She also emphasized the value of interdisciplinary education, as science, law, management, and communication prepare youth for multifaceted challenges, but that should be proceeded by *"finding one subject you feel really comfortable and good at"*. It is also vital for young people *"to ask for tasks and projects, succeed and go further"*, and start to create their networking group as early as possible.

Gopichand Thotakura, Astronaut of Blue Origin New Shepard-25 mission, emphasizes that worthiness is not about age or background but passion and opportunity. *"I don't believe that whether it's space tourism, an orbital mission, or furthermore, the worthiness is in every individual who contributed to that person going into space",* he added. What is important is for every single person *"to realize the potential of being able to contribute"*. When asked what advice he would give to the doubtful youth, he stated *"that they should never be discouraged from doing something they love; it can be anything"*. He also added that *"you shouldn't discourage your friend who's next to you, and that's very important"*. What matters the most, in the end, is *"the power of unity, the power of being together"*, he added. Reflecting on the impact of the event organized by the International Astronautical Federation, he said: *"I have never seen a place like yesterday where there were eight countries represented on one stage with people making a significant impact in each of their domiciles, and that's huge. That's monumental. That's the power of unity - to bring together so many people on one platform and try to deliver a strong message"*, which gains even more importance in the context of India, as *"it is very hard to do mass marketing"* and promote events with such an incredibly vast outreach. *"If there is a will, then you are already there"*, he quoted NASA's legend, Katherine Johnson.

The journey beyond Earth is a collective endeavour, and every individual's contribution counts. Whether through scientific discovery, policymaking, engineering, or advocacy, the next generation holds the key to unlocking space's full potential. Let us support, mentor, and empower youth to dream big and act boldly - the future of space exploration depends on it.

The IAF International Astronauts Chapter

The third edition of the IAF International Astronauts Chapter was one of the defining highlights of the IAF Global Space Exploration Conference (GLEX 2025).

As humanity's frontline explorers, astronauts embody the ambition, courage, and responsibility required to expand our presence beyond Earth. Through the IAF International Astronauts Chapter, the IAF provides a unique platform that showcases astronauts' expertise in shaping a sustainable, inclusive, and forward-looking future for global space exploration.

Jointly organized by the International Astronautical Federation (IAF) and the Indian Space Research Organisation (ISRO), a proud IAF member since 1989, the Chapter brought together an exceptional group of ten astronauts from around the world and added a truly human and inspirational dimension to a conference built around the theme "Reaching New Worlds: A Space Exploration Renaissance."

Throughout the conference, the distinguished astronauts participated in a variety of high-impact activities. Their collective presence offered a rare opportunity to witness a panel composed of individuals who represent important "firsts" in their nations' human spaceflight journeys - among them the first Emirati astronaut, Hazzaa Al Mansoori; the first Turkish astronaut, Alper Gezeravcı; and India's pioneering astronaut and national hero, Rakesh Sharma, who flew in space in 1984.

The programme featured a flagship Astronaut Panel within the IAF Global Networking Forum (GNF) titled "Life Between Worlds – The Astronauts' Experience". The session closed with a rapid-fire question to the speakers: "The future of space exploration is..."

The astronauts responded with powerful one-word answers - each reflecting their personal vision: ACCESSIBILITY (Gopichand Thotakura), BEYOND THE SKY (Alper Gezeravcı) BRIGHT (Michael LÓPEZ-ALEGRIA), COLLABORATION (Rakesh Sharma), CULTURAL (Angad Pratap), EXCITING (Eytan Stibbe), HERE (Sirisha Bandla), and TOGETHER (Hazzaa Al Mansoori).

IAF International Astronauts Chapter

As part of the outreach programme, the Indian Institute of Technology Delhi (IIT Delhi) and the International Centre for Genetic Engineering and Biotechnology (ICGEB) hosted their long-awaited meetings between the esteemed space explorers and students to spark curiosity, fuel ambition of future space scientists, engineers, and explorers.

A special Questions & Answers event, “Mission to Inspire: Astronauts & You”, was organized exclusively for school children from New Delhi. More than 300 young minds met astronauts for the first time in their lives. During this dynamic session, astronauts shared personal stories from space, and encouraged students as humanity prepares for its next great steps across the solar system.

Additionally, the Chapter programme included an autograph session with the astronauts on Public Day, 9 May - a rare and exciting opportunity for attendees to interact personally with space heroes.

GLEX 2025
Closing Ceremony

The IAF GLEX 2025 conference, hosted in New Delhi, India, marked a historic milestone in global space exploration. Over three intensive days, the event brought together thousands of participants, including scientists, space agency representatives, industry leaders, students, and astronauts, to celebrate achievements, share innovations, and chart the future of humanity's journey into space.

"All good things come to an end", mentioned Christian Feichtinger, IAF Executive Director and Master of the Ceremony. Both he and Clay Mowry, IAF President, extended their gratitude to ISRO, the host of the event and the Astronautical Society of India (ASI), a co-host. Mowry reflected on all major topics that have been touched upon, namely cooperation, democratization and equality in access to space. He also highlighted some of the statistics. *"GLEX 2025 witnessed over 1500 participants, 350 delegates and 550 students, which is probably a new record for GLEX or a global space event"*. Feichtinger shared with the audience the highlights video, a traditional part of all events organized by the International Astronautical Federation, thanking the filming team FILMAA for their *"excellent job of creating the legacy of our events"*.

The findings and the outcomes of the GLEX 2025 conference were presented by the GLEX 2025 conference IPC (International Programme Committee) Co-Chairs, Pascale Ehrenfreund, President of the Committee of Space Research (COSPAR) and Research Professor of Space Policy and International Affairs at the Space Policy Institute/George Washington University in Washington DC and Victor Joseph, Associate Scientific Secretary & Director, Technology Development & Innovation at ISRO. Ehrenfreund highlighted the huge interest in GLEX 2025 with the *"record high number of 1,275 abstract submissions, covering a wide range of topics from deep space exploration to space economy, space stations, the impact of artificial intelligence and many others truthfully"*. Six high-level plenary sessions *"upheld the highest standards, showcasing cutting-edge developments, future technologies, and policy developments from around the world"*. An additional forty presentations were made during the Technical Programme sessions and two interactive presentation sessions. Joseph explained the four key criteria for accepting the submitted abstracts: *"the scientific or technical quality, the direct applicability to space, the originality and creativity of the work, and the visual quality of the presentation"*.

The IPC Co-Chairs then proceeded to announce the prestigious awards. The Bronze Award went to Nidhi

Nidhi from India for her presentation, Exploring the Moon with Hopping Robots: Enabling, Efficient, Dynamic Mobility for Lunar Surface Exploration. The Bronze medal was awarded to Diego Pérez Reyes from Mexico for his work Optimizing Deep-Space Operations: The Impact of LuzIA on Crew Communication and Productivity. The winner of the Golden Award, Dai Asoh from Japan, presented a paper entitled Lunar Polar Exploration (LUPEX) Project. The latest status of the project. Thanking all the presenters, Ehrenfreund said: *"your passion and hard work elevate our community and inspire future advancement in space exploration"*.

Expressing once again his gratitude to the host (ISRO) and the co-host (ASI) of the event, Christian Feichtinger, IAF Executive Director, honoured Anil Kumar, Vice-President: Relations with International Organization at Indian Space Research Organization (ISRO), saying that *"you were instrumental to making this conference happen and making this conference a big success"*. Kumar highlighted that we *"had a fantastic conference that had already created history"*. He expressed his appreciation to the event organiser, the International Astronautical Federation, and V. Narayanan, the Chairman of ISRO and the Department of Space. He also set apart *"three pillars"* in making the conference possible: D. K. Singh, Director of Human Space Flight Centre, who led the local organisation committee; Jerry Calvin, the Member Secretary for the Local Organising Committee; and Vinod Kumar, Executive Secretary of Astronautical Society of India, who managed and chaired the finance committee.

The ceremony finished with a special acknowledgement for the International Astronautical Federation (IAF) Secretariat staff members in appreciation for being an event organizer and invitation for the upcoming IAF events: the 2025 International Astronautical Congress in Sydney and the GLOC 2026 (Global Space Conference on Climate Change) Conference in Kigali, Rwanda.

The GLEX 2025 conference not only celebrated the milestones achieved but also set a new standard for international collaboration in space exploration. It demonstrated that *"together, we go farther"*, emphasizing unity, diversity, and shared purpose. The event fostered meaningful connections, showcased cutting-edge research, and inspired the next generation of explorers. As the conference concluded, participants left with a renewed commitment to harness space technology for the *"benefit of humanity and Earth"*. The legacy of GLEX 2025 will undoubtedly influence future missions, policies, and collaborations, propelling humanity toward a brighter, more interconnected space-faring future. ■


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International Astronautical Congress

29 September - 3 October 2025 | Sydney, Australia

IAC 2025
Opening Ceremony

The 76th International Astronautical Congress (IAC 2025) opened in Sydney on Monday, 29 September, with a ceremony that wove together Indigenous culture, international collaboration, and Australia's growing space ambitions.

Organised annually since 1951 by the International Astronautical Federation (IAF) and hosted this year by the Space Industry Association of Australia (SIAA) with co-hosts the Australian Space Agency and the New South Wales Government, the IAC welcomed nearly 8,000 delegates from 99 countries. This year marked only the sixth time the Congress has convened in the Southern Hemisphere and the third time in Australia, following the 49th IAC in Melbourne in 1998 and the 68th IAC in Adelaide in 2017.

The cultural segment of the Opening Ceremony paid homage to Australia's traditional custodians, with a special acknowledgement of the Gadigal People of the Eora Nation, as well as other First Nations communities, highlighting cultures that date back tens of thousands of years. The significance of this acknowledgement was heightened in the context of the IAC. As noted by Keegan Buzza, Director of Community Engagement at the Australian Space Agency and Master of Ceremony, Indigenous Australians have *"looked to the skies for more than 60,000 years to navigate life here on Earth"*.

Clay Mowry, President of the International Astronautical Federation, addressed the packed room with reflections on the journey to Sydney and his concluding tenure. Acknowledging the vast distance many delegates travelled, he remarked that *"it actually took some longer to get here than it would for an astronaut to reach the International Space Station"*. He also highlighted the region's growing prominence within the global space sector, noting that *"over one quarter of our IAF Members are now coming from this part of the world"*. Thanking the host and co-hosts, as well as IAF's partner organisations: the International Institute of Space Law, the International Academy of Astronautics and the Space Generation Advisory Council, and acknowledging Australia's First Nations, he emphasised this year's theme, *"Sustainable Space, Resilient Earth"*, reflecting both extraterrestrial ambitions and terrestrial responsibilities.

Jeremy Hallett, Chair of the Space Industry Association of Australia and Chair of the IAC 2025 Local Organising Committee, drew attention to the remarkably high participation of young professionals and students, who make up half of this year's delegates. He highlighted the versatility of the theme, which should be explored in three dimensions: sustaining life on Earth, ensuring sustainable access to space for future generations, and learning to sustain life beyond Earth. Echoing Mowry, he emphasised strong attendance from the Indo-Pacific region, demonstrating the *"ambition, creativity and momentum"* of the region and its essential role in the global space community. He also reminded attendees that space technologies are "the foundation of all of our modern life".

The ceremony featured a distinguished lineup of personal testimonies from individuals who have shaped Australia's recent space history, including space historian Karrie Dougherty, *"human computer"* Heather Milhench, creator of the first Australian satellite Owen Mace, satellite programme specialist Gordon Pike, space tracker John Saxon, and space industry leader Roger Franzen. Appearances were also made by Paul Scully-Power, the first Australian in space, and Katherine Bennell-Pegg, the first astronaut trained under the Australian flag. Representing the future of Australia's space sector were Enrico Palermo, Head of the Australian Space Agency, and Tully Mahr, National Indigenous Space Academy alumna.

Governor-General Sam Mostyn delivered extended remarks on Australia's evolving space identity, describing the nation as *"braiding millennia-old custom, law and practice with modernity"*, forming a unique three-part national story: continuous Indigenous history, stability underpinned by a strong democracy, and a modern chapter of optimism and progress driven by multiculturalism. She highlighted individual achievements, including Bennell-Pegg's, as sources of national inspiration, strengthened by collective effort and flourishing international collaboration. Inviting attendees to seize the opportunities presented by the Congress, she said: *"Let's look forward to a wonderful, sustainable, peaceful future in space."*

The ceremony also featured the presentation of the prestigious IAF Awards, announced by Asanda Ntisana, IAF Bureau Member, Vice-President for Honours and Awards and Acting Managing Director for Earth Observation at the South African National Space Agency (SANSA). Jeff Bezos of Blue Origin received the IAF World Space Award (Individual categoty), accepted on his behalf by Phil Joyce, Senior Vice-President for New Shepard at Blue Origin, who noted Bezos's lifelong passion for space and Blue Origin's vision of *"millions of people living and working in space for the benefit of Earth"*. The Team Award was bestowed on China's Chang'E-6 mission, with Chief Designer Hu Hao accepting the trophy and emphasising that *"exploring the universe and enhancing human well-being is our endless dream to pursue"*. The 2025 IAF Excellence in International Cooperation Award was presented to Pascale Ehrenfreund, President of the Committee on Space Research (COSPAR) and Research Professor of Space Policy and International Affairs at the Space Policy Institute, George Washington University. She noted that despite rapid commercial growth and new nations joining the spacefaring community, "international cooperation is the key to progress", and that achievements are measured not only in technology, but in *"the trust we build, the data we share, and the shared vision we inspire"*.

The IAC 2025 was officially inaugurated by Chris Minns, Premier of New South Wales, who framed space exploration as a universal endeavour, the impact of which-though not always tangible-underpins modern society. He expressed gratitude for the strong international presence at the Congress, noting that it will inspire younger generations, and highlighted that *"the progress made at this conference will touch every life on Earth every day of the year"*. He also underscored that international collaboration remains essential for continued success.

The ceremony concluded with Buzza encouraging participants to explore the space-themed activations across Sydney and to join the upcoming sessions and Welcome Reception. The event balanced deep respect for ancient astronomical traditions with excitement for future space endeavours, setting a collaborative and inclusive tone for the week ahead, and was enriched by a video message from astronauts aboard the International Space Station.■

> "Exploring the universe and enhancing human well-being is our endless dream to pursue"

IAC 2025

Plenaries

PE

One-to-One with Heads of Agencies

The IAC's Opening Plenary is a prestigious and unique in the global scale platform where leaders of the world's top space agencies gathered to discuss their organisations' achievements, plans, and challenges.

Head of the Australian Space Agency, Enrico Palermo, acknowledged the Gadigal People and emphasised how millennia of First Nations knowledge enrich the nation's journey to the stars. He stated that *"our space sector now has heritage in space and is ready to scale."* With strong international collaborations and significant contributions, the country has become *an experienced,* trusted and capable partner in an increasingly complex global landscape.

What followed was a series of one-to-one interviews conducted by Palermo and IAF President Clay Mowry. The Moon emerged as the session's gravitational centre, drawing together themes of exploration, commerce, and international cooperation.

National Aeronautics and Space Administration (NASA) Acting Administrator Sean Duffy framed America's return to the lunar surface as both a historic milestone and an economic catalyst, with the Artemis Programme serving as the cornerstone of NASA's continuous human space exploration. With the vast potential of a growing space economy and strengthened industrial partnerships, Duffy was optimistic not only about returning to the Moon but achieving long-term sustainable presence at the lunar South Pole. Plans for Mars and deep-space exploration remain in focus, as "it is in humans' hearts. Humans want to explore", but these ambitions must be balanced with nearer-term goals. He further emphasised the value of international partnerships, stating *"we should be transparent and we should come in peace (...) as one human race"*.

That collaborative imperative found one of its strongest voices in Josef Aschbacher, Director General of the European Space Agency, whose 23 Member States underscore cooperation by design. *"I really believe that the strength of Europe is in its unity, its collaboration"*, he said, cautioning against national fragmentation. The year 2025 marks a major milestone for ESA, with its 50th anniversary and the release of Strategy 2040 with its top priority of planetary protection, a principle shaping both technology and partnership decisions. Aschbacher also underlined Europe's need for autonomy and resilience, clarifying that *"autonomy and more independence do not exclude international cooperation. They go hand in hand."* This is reflected in more than 320 cooperation agreements already signed, reinforcing ESA's role as a reliable global partner.

V. Narayanan, Chairman of the Indian Space Research Organisation (ISRO), reiterated the agency's founding purpose: *"From the beginning of the Indian space programme, our major focus was on utilising the advanced technology of space for the benefit of the common man of our country."* He highlighted ISRO's contributions to 14 of the 17 UN Sustainable Development Goals (SDGs) and India's growing commercial sector through IN-SPACe (Indian National Space Promotion and Authorisation Centre). Following the historic Chandrayaan-3 landing near the lunar South Pole in August 2023, Narayanan is already looking ahead to Chandrayaan-4's sample return mission and LUPEX, a joint initiative with JAXA. The Gaganyaan human spaceflight programme, targeting a crewed mission in 2027, adds yet another dimension. Despite progress, Narayanan emphasised the continued importance of international support.

> “Autonomy and more independence do not exclude international cooperation. They go hand in hand.”

“Space isn’t a luxury for Canada. It’s a necessity,” said Lisa Campbell, President of the Canadian Space Agency (CSA), citing Canada’s vast geography and the need for space technology to monitor natural disasters, particularly as they intensify with climate change. She also addressed increased national defence spending and the dual-use potential of space technologies. Canada continues adapting to a shifting global trade and industrial landscape with a focus on flexible solutions and trusted partnerships. While outlining the future of Canadarm technologies, she echoed previous speakers in stressing that *“we know that we go further together”*.

Zhigang Bian, Vice Administrator of the China National Space Administration (CNSA), outlined an ambitious national programme that included 72 launches in the past year. He noted that Chang’E-5 lunar samples have been made available to international researchers, with plans to do the same for Chang’E-6 and the Tianwen-2 asteroid sample return missions, highlighting China’s openness to global collaboration. He emphasised climate monitoring through more than 500 remote-sensing satellites and stated that China *“always upholds the principle of openness, inclusiveness and win-win cooperation, and is deeply involved in global climate governance.”* Bian also discussed the Tiangong Space Station, increased human space activity, and the risks posed by mega-constellations. He stressed China’s adherence to the UN Guidelines for the Long-Term Sustainability of Outer Space Activities and ongoing research into active debris-removal technologies.

President of the Japan Aerospace Exploration Agency (JAXA), Hiroshi Yamakawa, highlighted his organization’s recent achievements including GOSAT-GW for greenhouse gasses monitoring, the LUPEX lunar mission (in cooperation with ISRO), the HTV-X cargo vehicle to the ISS, and the Martian Moons Exploration (MMX) mission to Phobos in 2026 with a sample return planned for 2031 - an approach distinctly Japanese in its precision and scientific rigour. Japan also contributes significantly to the Artemis Programme, particularly the Gateway project. Yamakawa emphasised partnerships with emerging space nations and longstanding cooperation with Australia on missions such as Hayabusa, noting such collaborations are *“fruitful for both sides”*. On global challenges, he spoke with candour: *“We are honestly struggling,”* he admitted, “but we would like to contribute to solving global issues like climate change and disasters.” JAXA’s work with Astroscale on active debris removal demonstrates not only technological capability, but readiness for operational action: *“If we wait, if we do nothing, there will be a big disaster, I’m sure”*, Yamakawa warned.

The session reflected a generational shift in space leadership. These were not Cold War rivals proving ideological superiority through launch vehicles, but leaders advocating inclusive frameworks, emerging nations, and greater representation from Pacific voices.

The Moon beckons with ice at its poles and the promise of sustained human presence. Mars lies beyond. Yet between aspiration and achievement are the hard realities: building the spacecrafts, negotiating treaties, removing debris, and ensuring that humanity’s expansion beyond Earth benefits more than just the nations wealthy enough to launch. The conversations suggested today’s space leaders understand this calculus, even as they wrestle with the political and technical challenges of turning ambition into action.

Beyond Integration: Building Earth-Sky Knowledge Infrastructure for Co-discovery in Space and Sustainability

In a conference hall overlooking Sydney Harbour, the Host Plenary began with an acknowledgment of the history of 65,000 years of astronomical observation performed by Australia's First Nations People

Kirsten Banks, a Wiradjuri astrophysicist and Lecturer at Swinburne University of Technology who moderated the session, set the tone by rejecting a premise that often confines indigenous knowledge to museum displays. "Culture is not ancient history. It is living, breathing and it's evolving," she told the assembled delegates.

Martin Nakata, Deputy Vice-Chancellor, Indigenous Education & Strategy at James Cook University delivered the session's intellectual architecture, identifying what he called four distinct indigenous knowledge assets that were developed by millennia: multi-generational observational datasets, integrated systems framework (which focus on multiple correlations), non-linear temporal analysis (which allow to identify patterns invisible to linear analysis) and place-based astronomical calibration which "provide vantage points for understanding Space-Earth interactions". He wasn't suggesting these assets are "superior" to Western science. Instead, he advocated for "collaborative reconstruction and co-discovery" to ensure sustainability of space and space exploration, as it "requires us to fundamentally expand how we approach space knowledge".

> "The path to sustainable space resilient earth isn't just technological. It's conceptual, encoded in frameworks we are only beginning to rediscover. And the future of space sustainability lies not in the stars alone, but the wisdom of those who have been reading them the longest."

Similarly, Laurie Rousseau-Nepton, Assistant Professor at the University of Toronto, encouraged integration of different fields of science and knowledge. She combines astrophysics, indigenous knowledge systems and studies in archeoastronomy to discover "how science and culture can inform and inspire each other". It is the approach that allows multidisciplinary, which is indispensable for deeper understanding of the Universe and leaving lasting and meaningful heritage for the generations to come. Rousseau-Nepton elaborated on her discovery of the One Hundred Generations Principle, a concept of doing science that does think not only about immediate results, but considers it also in the long-term perspective, allowing us "to use a lot of it for space exploration and how we use environmental space around the Earth", she concluded.

New Zealand's perspective arrived through David Perenara-O'Connell, Chair of the Board and Te Taumutu Rūnanga Representative of Tāwhaki Joint Venture. He introduced new model for aerospace innovation, rooted in both indigenous values, culture and Western science, highlighting that his ancestors observed the skies before invention of the telescopes, crossed the oceans before established navigation systems existed and *"knew that everything in the Universe is connected through the genealogical relationships that bind us all together"*. He encouraged the audience to think about a paradigm shift proposed by Tāwhaki Joint Venture, in which all assets are working together in *"approaching aerospace in a way that protects and revitalizes the surrounding environment"*. While admitting the initial feeling of the imposter syndrome when faced with established aerospace institution, Perenara-O'Connell reflected that indigenous knowledge remains *"valid, rigorous, and deeply relevant to the future of Earth and space alike"*. What is more, *"many of the challenges the space industry faces, sustainability, systems thinking, long-term stewardship, are precisely what indigenous peoples have been mastering for millennia"*. He mentioned the examples of cooperations with Dawn Aerospace *"to gather data and intelligence following Tāwhaki's example of using technology to forge new relationships with celestial bodies"* and with Kea Aerospace and NASA to *"improve methods to monitor water quality"*. Working within such a framework allows space technology to *"become a means to heal, restore and rejuvenate what defines and identifies us as Tangata whenua, people of the land"*. Declaring the concept as indigenous futurism, Perenara-O'Connell concluded: *"We're not choosing between preserving traditional culture*

and advancing into space. We're creating infrastructure where space technology can strengthen connections to place, to ancestors, to the natural world that has sustained us for generations".

Reuben Bolt, Professor and Deputy Vice-Chancellor, Indigenous Strategy and Services at the University of Sydney, works *"at the intersection of indigenous knowledge and future facing innovation"*. The message he insisted of being heard and listened to is that *"indigenous knowledge is an asset to the world and a gift to humanity"*. He elaborated on the examples of Australian case studies that portray perfectly the potential collaboration between Western science and indigenous knowledge, which can serve to solve the most pressing issues of our times. Amongst the case studies was a concept of painting with fire (where fire is understood as creation, rather than destruction) and rain stick, which is *"using electricity to mimic the natural effects of lighting to grow crops bigger, faster and more sustainably."* He invoked proofs, stating that *"satellite imagery confirms that areas managed with cultural fires are more resilient to climate extremes"*; He added that *"when we listen, learn and collaborate, we unlock solutions that are holistic, contextualized, and deeply respectful of country"* and can be used for space farming *"where resources are limited and sustainability is critical"*.

Throughout the presentations, a tension emerged between integration and transformation. Enrico Palermo, Head of the Australian Space Agency, acknowledged this explicitly in his opening and closing remarks. *"We at the Australian Space Agency have been on a journey with five extraordinary respected Indigenous leaders, now joined by Canadian and New Zealand experts to design and deliver this plenary which invites us to go beyond integration to build Earth sky knowledge infrastructure for co-discovery,"* he said. The phrase *"beyond integration"* carried significance. Integration implies adding indigenous perspectives to existing frameworks. Co-discovery suggests building new frameworks entirely and *"growing better futures"*.

The session's most powerful moment came near its conclusion, when Dean Sanders, Worimi Giparr and Special Counsel at Deloitte Access Economics and Alvin Harvey, Diné of Navajo Nation and Postdoctoral Fellow at the Massachusetts Institute of Technology (MIT) Media Lab presented a message stick for an on behalf of the global space community, which contained encoded information that Sanders described as requiring several PhDs to unpack.

The gesture of entrusting this stick to the International Astronautical Federation carried ritual weight, as the space sector now carries guardianship not just for orbital assets and exploration missions, but for knowledge systems it has only begun to understand.

Palermo's closing challenge went directly to the assembled engineers, scientists, and policy makers. *"I ask you to grasp this moment with courage, with clarity and together over these 12 months, let's unlock new frontiers of discovery,"* he said. The timeline was deliberate. This wasn't a call for symbolic gestures at the next congress. It was a mandate for structural change, that achieving sustainable space and resilient Earth might require not just new technologies or better policies, but different ways of knowing entirely.

How a Circular Economy Framework Unlocks Commercial Success in Spaces

In an era when space debris threatens the very orbital highways that enable modern life, industry leaders gathered at the 76th International Astronautical Congress to discuss a radical reimagining of how humanity conducts business beyond Earth's atmosphere. The third Plenary session revealed an emerging consensus: the path to a trillion-dollar space economy runs not through endless manufacturing and disposal, but through reuse, repair, and regeneration.

The stakes could not be higher. As Tim Parsons, Board Member of the Space Industry Association of Australia and session moderator, framed it, the challenge is *"preserving the commons and ensuring that the Earth orbit and the orbits around the Moon and Mars and beyond are things that we can continue to use and enjoy and benefit from for all humanity."* The question facing the panel was whether circular economy principles, long championed on Earth, could transform space from a disposable frontier into a sustainable ecosystem.

Chris Blackerby, Group COO of Astroscale, opened with a corrective that set the tone for the entire discussion. *"We are not a debris removal company,"* he stated firmly, pushing back against a common misconception. *"Debris removal is a part of what we do, but we're looking at all aspects of on-orbit servicing."* His Tokyo-headquartered company, with profit-and-loss responsible entities spanning Japan, the UK, France, and the United States, is building the foundational capabilities that could unlock what he called "this multi-trillion-dollar orbital economy that's coming."

The company's current missions showcase the technical breakthroughs making circular space economics possible. Astroscale is operating ADRAS-J, conducting close-up inspection of a non-cooperative, non-communicative Japanese rocket body. The company recently secured NASA's contract to boost the aging Swift telescope, extending the scientific life of critical infrastructure. Next year will bring a Space Force refuelling mission. These aren't disparate projects but demonstrations of what Blackerby identified as the sector's core technology. As he sees it, *"rendezvous and proximity operations and docking with an object in orbit is going to open up the aperture for all aspects of on-orbit servicing."*

The circular vision extended beyond Earth orbit. Dana Baki, Chief Commercial & People Officer at The Exploration Company, described her Europe-based firm's integrated approach spanning LEO, cislunar space, and eventually Mars. The company is simultaneously developing NEACS, a re-entry capsule scheduled to dock with the ISS in 2028;

> “We need to think about how we can reuse satellites, how we can extend their lives, and how we can make sure that we’re not just throwing things away.”

lunar landers set for ground demonstration in the UAE in early 2027; and a reusable launcher. *“Circularity is really important to each part of that,”* Baki explained. *“It’s the reason why we are getting into each and every one of them because we realize how interconnected they need to be and how building a modular system can really help build scale across all three.”*

This interconnection emerged as a central theme. The circular economy isn’t just about reusing individual satellites, it’s about creating modular, standardized systems where components can move between applications. As the discussion revealed, we’re witnessing the early stages of what could become an orbital logistics network, where spacecraft don’t just complete missions and die but serve as assets that can be refuelled, repositioned, upgraded, and repurposed.

Max Haot, CEO of Vast, brought the human dimension into focus. His company is building what he expects will become the world’s first commercial space station when Haven-1 launches next year. The transition from government-operated to commercial platforms represents more than a business model shift; it’s the creation of reusable infrastructure that can host multiple customers across decades. *“Without that transition to go from cost plus contract to fixed firm price and the ability for us to buy a Dragon spacecraft to bring crew to our future destination, we would not even exist,”* Haot noted, crediting SpaceX’s commercial crew program with enabling the next generation of space companies.

Vast shipped its 500-kilogram demonstration satellite to the launch site the week before the Congress, with a flight planned for later in the year. Haven-1 has completed welding of its primary structure and is moving toward proof testing and integration, fully funded including a SpaceX flight carrying a crew of four for a two-week mission. The company is competing for NASA’s Commercial LEO Destination phase two competition, with awards expected as early as March 2026. But Haot emphasized that Vast’s business model requires more than American customers. *“We don’t have a sustainable business model without international customers and international collaboration. With just NASA or the US market, we cannot exist,”* he stated, aligning economic incentives with the collaborative spirit that has defined orbital operations since the ISS era.

Jeffrey Hendrikse, Co-Founder and CTO of ATMOS Space Cargo, addressed the often-overlooked logistics layer that could make this circular vision practical. His company is developing space tugs capable of carrying up to one ton of cargo while providing power and data services. ATMOS recently secured an ESA contract to develop propulsion systems for the Hera mission to the Dimorphos asteroid. *“We need to rethink the way we do business in space,”* Hendrikse argued. *“We need to think about how we can reuse satellites, how we can extend their lives, and how we can make sure that we’re not just throwing things away.”*

The discussion turned technical when examining what makes reuse possible. The panel noted that 3D printing is already happening in orbit, opening possibilities for in-space manufacturing that could eliminate the enormous waste inherent in designing satellites to fit within launch vehicle fairings. As Parsons observed, we expend tremendous effort fitting satellites into *“rocket nacelles for the first five minutes of their life,”* when assembly in orbit could eliminate these constraints entirely.

Yet technical capability alone won’t create a circular space economy. The conversation touched on thorny questions about standardization, with the panel acknowledging that while common interfaces would benefit the industry long-term, current competitive dynamics favour proprietary systems. The regulatory framework remains underdeveloped for emerging activities like satellite refuelling, life extension, and in-space assembly.

The ethical dimension surfaced in a pointed question to Haot about maintaining the Outer Space Treaty’s principles in a *“full capitalist space station.”* His response revealed how economic reality and idealism might align. *“What if we could do the same level of international collaboration, next level involving more countries, but do it materially cheaper for all the taxpayers in these countries,”* Haot suggested, positioning commercial stations not as replacements for the ISS’s collaborative model but as more sustainable implementations of it.

As the space sector races toward what all panellists described as a multi-trillion dollar orbital economy, this session revealed an industry grappling with fundamental questions about sustainability. The circular economy framework they’re building, through reusable launchers, life-extension services, modular systems, and commercial infrastructure, suggests that the future of space may be less about conquering new frontiers and more about stewarding the orbital commons we already have. The challenge now is whether this vision can move from demonstration missions and business plans to the mature, reliable sector that makes a sustainable space economy possible.

Learning to Live on Another World: The International Community's Return to the Moon

In a room filled with engineers, astronauts, and dreamers from across the globe, Jason Kalirai, Mission Area Executive for Space Formulation within the Space Exploration Sector at the Johns Hopkins Applied Physics Laboratory (APL), posed a question that defined the stakes of humanity's lunar ambitions. Standing before an image of Earth's barren satellite, he reflected on how his two daughters have never known a world without humans living in space. *"Our challenge is how we will be defined in this period,"* said Kalirai. *"It's whether or not we can take the next steps in humankind's exploration and learn to live on another world and moreover, learn to sustain that presence with the natural resources of the Moon."*

The contrast was stark: Earth, with its cities and accumulated infrastructure, versus the Moon, still undeveloped despite being our nearest celestial neighbor. Yet as the fourth plenary demonstrated, that emptiness represents possibility. The session brought together leaders from NASA, ESA, JAXA, Firefly Aerospace, and the Australian Space Agency to address the defining challenge of transforming the Moon from a destination we visit into a world where we live.

The urgency was palpable. In just the past few years, China, Russia, India, Japan, Israel, and the United States have attempted lunar landings, some multiple times. China's Chang'E-6 mission successfully retrieved samples from the lunar far side, material so recently returned that attendees could view it at the congress exhibit hall. This acceleration signals a fundamental shift in how humanity views its relationship with the Moon.

Frank De Winne, Head of European Astronaut Center and ESA's first astronaut to command a space mission, outlined Europe's phased approach extending decades into the

> "When we talk about international community returning to the Moon, we've already demonstrated we can do this robotically. And the next step is to do it with humans as well."

future. ESA has already delivered three service modules for NASA's Orion spacecraft and is preparing habitation modules for the Gateway lunar outpost. *"We have had a permanent human presence in space for 26 years,"* De Winne noted. *"But it's time indeed to make the next step. We need to go forward to the Moon. Not just to plant a flag or to be the first, but we need to go there to sustain, to learn, to do science, to work, to operate."*

The timeline is ambitious but grounded in hardware already under development. Nujoud Merancy, NASA's Deputy Associate Administrator for Strategy and Architecture, brought that reality into focus with updates on the Artemis program. Artemis II could launch as early as February, she announced, taking four astronauts on the first crewed mission beyond low Earth orbit in over 50 years. *"The reality of going to the Moon is now,"* Merancy emphasized. *"We used to call these baby pictures, but I think we're taking graduation pictures now of all of our hardware."*

Her presentation detailed NASA's focus on the lunar South Pole, where continuous lighting can last up to six months and water may be trapped in the regolith. Yet crew time represents the most precious resource in any exploration mission. *"The more we can make the crew successful to do the geological exploration, to do the human research, to understand medical conditions, that's the value of the crew being there,"* Merancy explained. *"It's not turning bolts to replace hardware."*

Japan's SLIM mission demonstrated how technical excellence unlocks broader possibilities. Masaki Fujimoto, Professor and Deputy Director General of JAXA, described the spacecraft's remarkable precision: just 3 meters of error at 50 meters altitude. Despite a contingency in the final 42 seconds, SLIM landed safely and deployed two miniature robots. *"Multiple spots on the surface of the Moon and Mars should be visited and studied intensively before we send astronauts,"* Fujimoto observed. *"Pinpoint landing by small lander is the way. Going there more often and more frequently is the best way to learn about the environment."*

Commercial involvement represents perhaps the most dramatic shift in lunar exploration. Will Coogan, Blue Ghost Chief Engineer at Firefly Aerospace, detailed his company's successful landing in March, when Blue Ghost Mission 1 became the first commercial vehicle to softly land upright on another planetary body. The journey from contract award to lunar surface took just four years. The mission experienced temperature swings exceeding 270 degrees Celsius, with unexpected challenges like a nearby crater magnifying sunlight back onto the vehicle. *"Beyond Low Earth Orbit, it's a very difficult industry to be competitive in,"* Coogan acknowledged. *"But I think the first thing is just to have something that you're passionate about. And if you're passionate about it, you can often find some commercial case, some use case for it, and then find others who share that passion."*

Australia's lunar program illustrates how space exploration transforms industries beyond aerospace. Arvind Ramana, Director of Space Programs at the Australian Space Agency, described the Moon to Mars Initiative where industry develops missions aligned with national objectives. *"The biggest draw card for Australian industry to get into space has been the spin off benefits,"* Ramana explained. *"If they're able to prove their technology works in space and on the Moon, they can also prove that it's going to work better here on Earth."* He offered a striking example: virtual reality tools developed for astronaut training are now used by major Australian supermarket chains.

The question-and-answer session revealed ethical complexities beneath the technical achievements. When asked about health risks from radiation and lunar dust, De Winne acknowledged the challenges candidly, noting that ESA's first two Gateway payloads will focus on radiation monitoring. Merancy emphasized the collaborative imperative: *"The challenges from low Earth orbit to the Moon to Mars are each an order of magnitude harder than the one before. So be clear about your strategic value to a larger ecosystem because it's an all of us effort to explore, not a one of us."*

Ben Greenhagen, Planetary Scientist at Johns Hopkins Applied Physics Laboratory and Chair of NASA's Lunar Exploration Analysis Group, closed with a historical perspective. He displayed an image taken by Mars Reconnaissance Orbiter on October 3, 2007, showing Earth and Moon from 140 million kilometers away. The significance resonated: JAXA's Selene mission entered lunar orbit that same day, beginning what has become a continuous robotic presence at the Moon. *"When we talk about international community returning to the Moon, we've already demonstrated we can do this robotically,"* Greenhagen reflected. *"And the next step is to do it with humans as well."*

The vision that emerged was simultaneously audacious and pragmatic. Panelists predicted permanent lunar settlements by 2035 and sustainable operations by 2045. Fujimoto imagined astronauts casually walking robot companions. Coogan hoped for people to call the Moon home. These aren't fantasies but extrapolations from hardware under construction, missions being planned, and partnerships already formed.

The transformation Kalirai described in his opening remarks is underway. His daughters take for granted that humans live in space. Their children will take for granted that humans live on the Moon. The challenge facing this generation is to make that transition not just possible but sustainable, not just a national achievement but a truly international endeavor, not just an engineering triumph but a foundation for humanity's expansion into the Cosmos. The message from the plenary was clear: the international community isn't just returning to the Moon. It's learning to stay.

Healing Earth, Envisioning Space: Indigenous Knowledge and Partnerships for a Resilient Future

In an unprecedented moment for the International Astronautical Congress, Indigenous leaders sat alongside space researchers to challenge a fundamental assumption underlying humanity's cosmic ambitions: that the path to space must repeat the same extractive patterns that have scarred Earth. The fifth plenary of IAC 2025 in Sydney marked not a token gesture toward inclusion, but a reckoning with what true partnership might demand from the space community.

> "Space technology should serve communities rather than extract from them."

"I was brought to tears with the amount of acknowledgement and sharing of culture from your lands and your peoples," said Ren Freeman, Eastern Shoshone Elder and Director of the Indigenous Research Center, opening the session. Her emotion captured something deeper than gratitude. Freeman had spent months in planning conversations with the Congress organizers, building the relationships that Indigenous cultures recognize as the foundation of any meaningful collaboration. *"That's relationship building," she said. "That joins our stories."*

The session, moderated by Alvin D. Harvey, a Diné of Navajo Nation and Postdoctoral Fellow from Massachusetts Institute of Technology (MIT), carried forward themes from the host plenary earlier in the week. But where that gathering introduced concepts, this one confronted hard truths. The elephant in the room was last year's controversy over plans to send human cremated remains to the Moon aboard a commercial spacecraft, a mission that never consulted the Navajo Nation despite NASA's promises to do so two decades earlier.

Buu Nygren, President of the Navajo Nation addressed the episode with measured directness. His nation spans roughly 69,000 square kilometers across Arizona, New Mexico, and Utah, established through an 1868 treaty with the United States government. *"The US government and the Navajo Nation put their differences aside and stopped fighting each other and said, you know what? How do we go from here and build the economy and build our communities up and let's move forward?"* Nygren recounted. Twenty years after NASA consulted his predecessor about lunar

missions involving human remains and promised to do so again, that consultation never happened.

"My predecessor in the late 90s also made a statement that sending human remains to the moon was not right," Nygren explained. The mission ultimately failed, but the breach of trust succeeded in crystallizing a broader question: Does the space community seek Indigenous consultation only when legally required, or does it genuinely want to transform how it operates?

Freeman pushed the audience toward uncomfortable self-examination. She works with eight values and philosophies drawn from her Shoshone worldview when collaborating with others. From the host plenary, she had identified three that resonated across Indigenous perspectives: responsibility, reciprocity, and relationship. *"How do we move with it as we come together around topics and subjects like we're here for?"* Freeman asked. *"How do we define sustainable space? How do we define resilient Earth? We have a conversation, and we figure that out together for this time, maybe different the next time."*

Nygren recounted how NASA once used Navajo landscapes to simulate Martian conditions for equipment testing. The relationship between Indigenous lands and space exploration runs deeper than most acknowledge. *"They would actually test a lot of their equipment using some of the landscapes that are within the Navajo Nation,"* Nygren noted. The Navajo word for Earth, *"Nehima Nahastan," translates as "our mother, the one that gives us everything that we could possibly ever want."* The sun is understood as the provider from beyond. *"Those concepts and those words have been around for hundreds and hundreds of years, well before the sun was studied, well before the earth was scientifically studied,"* Nygren observed.

This wasn't romantic nostalgia. Nygren was making a point about epistemology, about ways of knowing that predate and perhaps exceed what Western science can offer. The space community treats Indigenous knowledge as something to be *"integrated"* into existing frameworks. Nygren suggested the framework itself might need changing.

Danielle Wood, Associate Professor at MIT, offered practical examples of what partnership could look like. She described collaborations between space agencies and Indigenous communities for environmental monitoring, tracking wildfires, water resources, and land use changes. But Wood emphasized a crucial distinction: *"We need to think about what we mean by indigenous knowledge,"* she said, stressing the importance of critical awareness in structuring partnerships.

Wood highlighted Indigenous data sovereignty, the principle that Indigenous Peoples should control how data about their lands and communities is collected, managed, and shared. The concept challenges standard operating procedures throughout the space sector. If Indigenous nations are data sovereigns over their territories, they cannot be passive subjects of remote sensing. They must be active partners in mission design, data analysis, and dissemination.

The practical implications are significant. Wood's examples showed how this works: Indigenous communities identifying what they need to monitor, space agencies providing technical capabilities, and both sides co-developing the questions and methods. *"Space technology should serve communities rather than extract from them,"* Wood said.

Nygren offered advice to both sides of potential partnerships. To Indigenous leaders, he urged openness when organizations approach them. *"If they're actually at your footsteps, they've knocked on the door, they've bought the powwow ticket, and they've got some fire bread in some hand, their hearts are probably in the right place. So sit down and listen to them and hear them out,"* he said. But he also challenged his audience: *"How can we expect them to listen to us if we're not willing to listen?"*

To space organizations, Nygren's message was direct: hire Indigenous people. He shared his own eight-year experience in construction management, where he *"educated my colleagues for the eight years that I worked for that organization. And they learned a lot about who Navajo people are, who Indigenous People are, who American Indian people are."* The approach works. *"Visit your local colleges, local universities, and really try to even possibly bring on a mentor,"* Nygren urged.

He also made a pitch for Indigenous engineers specifically. *"Engineers are a very solution-oriented type of people,"* he noted, observing that Congress attendees *"are not really here to complain about not solving a problem. They're just here to figure out how do we resolve a problem; how do we try and try and try until we figure it out."*

The session concluded with Harvey passing a ceremonial stick back to Deen Sanders, symbolizing the continuation of the conversation beyond the Congress. *"We hope to be back. We hope to have a Navajo Nation space agency. We hope to have IAC welcome us back. Maybe an indigenous session one of these days as well,"* Harvey said.

The gathering offered no easy answers about what meaningful partnership looks like, but it succeeded in making clear what it isn't: consultation as box-checking, knowledge as resource extraction, or participation as token presence. The path forward, speakers suggested, requires humility and recognition that Indigenous Peoples are not emerging space nations requiring assistance but original members of the space community whose knowledge has always reached toward the stars.

Designing the Future of Human Spaceflight

As humanity stands at the threshold of a new era in space exploration, a younger generation of professionals gathered at IAC 2025's sixth plenary to articulate a vision markedly different from the one that built the International Space Station. The session, titled "Designing the Future of Human Spaceflight," brought together designers, researchers, and analogue mission veterans who are reimagining not just the hardware of space travel, but the very philosophy behind it.

The conversation, moderated by Hilary Coe, Chief Design and Marketing Officer at Vast, revealed a field grappling with fundamental questions about inclusivity, sustainability, and the transfer of knowledge between extreme environments on Earth and in space. Unlike traditional technical sessions focused on propulsion systems or life support, this plenary cantered on the human experience of spaceflight and the ecosystems that will support it.

Brenden Swanik, Host and Mission Manager at Voyager Technologies, framed the central challenge facing the industry. Having launched 40 satellites from the International Space Station and built a media platform reaching 10,000 individuals from 75 nations, he identified a critical gap. *"There are so many players in this industry internationally and there may be a gap in communication,"* Swanik said, highlighting how the explosive growth in commercial spaceflight has created silos where open dialogue once existed.

This fragmentation emerged as a recurring concern throughout the session. Nadine Duursma, a double MSc Candidate in Robotics and Space Engineering at Delft University of Technology, offered a pointed warning about the direction of human spaceflight. *"My main concern is that we're going separate and that we're not going together,"* she said, contrasting current national programs with the collaborative spirit that built the ISS. Her observation struck at a deeper tension: as more nations and companies

> "I always feel like we're in a whole new golden space age right now. We have the motivation, we have the people, we have the expertise, and we have the funding coming in for now."

pursue independent space programs, the unifying power that once characterized human spaceflight risks fracturing along political and commercial lines.

Yet the panellists also identified powerful forces pulling in the opposite direction. The integration of artificial intelligence into spacecraft design revealed both promise and peril for inclusive exploration. Duursma raised questions that would have seemed marginal a decade ago but now sits at the centre of design philosophy. *"Have you ever wondered why AI voices are always female?"* she asked. *"It's because they're perceived to be more helpful and assistive. But if you listen too often to it can also introduce biases."* Her point extended beyond voice interfaces to a broader critique of space systems designed around assumptions that exclude large portions of humanity. The revelation that spacecraft systems are tested primarily on male mannequins prompted her to wonder how many men would board a craft if the situation were reversed.

The discussion of analogue missions provided concrete examples of how Earth-based research is reshaping approaches to long-duration spaceflight. Ashley Kowalski, Project Leader for International Programs at the Aerospace Corporation, brought firsthand experience from multiple analogue simulations, including the eight-month Sirius 21 mission. *"During the eight-month isolation, we studied the effects of isolation and confinement on human psychology, physiology, crew dynamics, crew autonomy and the general behavioural health of our crew members,"* Kowalski explained, describing a multinational effort involving NASA's Johnson Space Center, Moscow's Institute for Biomedical Problems, and the UAE's Mohammed Bin Rashid Space Center.

These analogue experiences are yielding insights that challenge conventional wisdom about crew selection and habitat design. Kowalski's subsequent work at the Mars Desert Research Station shifted focus from psychological factors to operational realities, examining *"the operational and experimental aspect of procedural needs for human interaction with different experimental setups."* Her research on microgravity's effects on circadian rhythms during parabolic flights demonstrated how seemingly peripheral concerns about body temperature and sleep cycles can cascade into mission-critical issues affecting astronauts health and performance.

The emergence of modular robotics as a design philosophy represents another departure from traditional approaches. Ashutosh Mishra, a Doctoral Researcher (MEXT Scholar) at Tohoku University's Space Robotics Laboratory, outlined a vision where flexibility trumps specialization. Working under the Japanese government's Moonshot Goal 3, Mishra's research asks what he calls "a basic question with big consequences: How do you turn a small set of modules into many mission-ready robots to help the astronauts?" His answer involves plug-and-play hardware with hierarchical learning systems that can reconfigure from crawlers to manipulators to lifters, working in teams under human supervision. *"My aim is direct: make modular robots' dependable teammates for the astronauts,"* Mishra stated, emphasizing how this approach could reduce EVA exposure and raise the tempo of lunar construction while allowing crews to focus on exploration and science.

The architectural dimension of space habitation emerged as perhaps the session's most provocative thread. Christina Balomenaki, Architect Engineer and Research Associate at the Transformable Intelligent Environments Laboratory (TUC TIE Lab) of the Technical University of Crete, articulated why designers from seemingly unrelated fields matter to spaceflight. *"Studying humans, their interactions, their habitats, the man-made environment in general in extreme conditions makes you understand what goes wrong with these things,"* she explained. Her work in Antarctica and other extreme terrestrial environments revealed patterns invisible in complex urban settings. *"If something is a problem in the extreme environments, it's also in the usual urban environments. But because of the complexity of the life of the surroundings, you don't understand it."*

This bidirectional flow of knowledge between space and Earth applications unified the panellists' closing reflections. Swanik offered a counterpoint to concerns about fragmentation by invoking a shift in public perception. *"Space is for Earth,"* he declared, citing his colleague, Dave Marsh. The evolution from viewing space as an expensive distraction to recognizing its terrestrial applications has accelerated dramatically. *"Just within STAR Lab alone, we're going to be able to grow organs and test on your tissue to see how you can use certain medicines and how your body accepts it,"* he said.

The session's final moments captured a sense of possibility tempered by awareness of persistent challenges. Kowalski, surveying the landscape of emerging commercial stations, international partnerships, and maturing technologies, expressed what many in the audience felt. *"I always feel like we're in a whole new golden space age right now,"* she said. *"We have the motivation, we have the people, we have the expertise, and we have the funding coming in for now."*

The panellists articulated a compelling vision of human spaceflight designed around inclusivity, modularity, and Earth benefit. Yet they had also identified formidable obstacles: the pull toward nationalist programs over international collaboration, the challenge of building truly inclusive systems in a field shaped by historical biases, and the ongoing difficulty of translating research insights into operational practice. As humanity prepares to return to the Moon and venture to Mars, this next generation of space professionals is insisting that how we go matters as much as whether we go at all.

Space Sustainability – Regional Priorities, Global Responsibility

> “The energy of young people is incredible.”

As debris from a Falcon 9 Dragon trunk scattered across Australian farmland and rocket fragments washed up on pristine beaches halfway around the world, the reality of space sustainability shifted from abstract policy concern to tangible threat. At the seventh plenary of the 2025 International Astronautical Congress, leaders from four continents gathered to confront a sobering truth: the decisions made today about space operations will determine whether future generations can access the orbital environment at all.

The session, facilitated by Heriberto Saldivar, Head of Strategy at the European Space Agency, brought together perspectives from established space powers and emerging nations alike. The diversity of viewpoints revealed that while space sustainability means different things across regions, the imperative to act transcends borders.

Enrico Palermo, Head of the Australian Space Agency, opened with stark statistics that underscored the urgency. Between 2021 and 2024, Australia experienced a fourfold increase in predicted debris reentries compared to the previous four years. *“We had a few large sections of a Dragon crew trunk section from Falcon 9 land in the snowy mountains in a farming region,”* Palermo noted. “If that had landed in a populated area it would have been a great concern.”

Yet Australia’s concerns extend beyond physical hazards. The nation’s Indigenous Communities have maintained celestial knowledge systems for thousands of years, finding meaning not just in the stars but in the spaces between them. *“The EMU in the sky is really the dust clouds in the Milky Way,”* Palermo explained, describing how light pollution from satellite constellations now disrupts these ancient cultural practices. Meanwhile, the Square Kilometre Array (SKA), positioned in Western Australia’s radio-quiet zone, faces an ironic predicament because as Palermo put it, there are *“increasingly no radio quiet sites on the planet.”*

For emerging space nations, sustainability takes on an even more urgent dimension. Gay Jane P. Perez, Deputy Director General for Space Science and Technology of the Philippine Space Agency (PhilSA), described a nation caught between desperate need for space-based data and vulnerability to space activities it does not control. The Philippines ranks among the world’s most disaster-prone countries, making satellite observations essential for survival. Yet this year alone, the Agency issued eight warnings about potential debris drop zones within Philippine waters.

The human cost of orbital debris materialized dramatically just two months before Congress. *"Rocket debris was sighted at a busy time, like 6:30 in the afternoon,"* Perez recalled. "People see it passing over and there are sonic booms heard, vibrations felt. So, it really affected the community." Philippine fishermen and coast guard regularly encounter large debris in their waters, while the country waits anxiously each time foreign rockets pass overhead. *"We advocate for increased transparency, coordination and maintaining responsible behavior for space,"* Perez stated, her words carrying the weight of a nation dependent on space systems it cannot fully protect itself from.

The European perspective added another layer of complexity. Josef Aschbacher, Director General of the European Space Agency, emphasized that Europe's rapid warming - occurring twice as fast as other continents - makes space-based climate monitoring not merely valuable but essential. *"Space has saved lives with our Copernicus system,"* Aschbacher noted, highlighting how satellite data enables everything from flood prediction to crop monitoring. Yet he also stressed the economic stakes: *"We also need space to support our economies."*

Europe's response has been particularly regulatory, with ESA's Zero Debris Charter attracting signatures from major players including Amazon and SpaceX. But Aschbacher acknowledged the limitations of voluntary measures. *"Regulation is necessary because if you leave it to voluntary contributions, there will always be free riders,"* he observed, though he cautioned against overregulation that might stifle innovation.

The American approach, as articulated by Alvin Drew, Director for NASA Space Sustainability, emphasized learning from past mistakes. Drew invoked the metaphor of the Internet, designed in 1969 without consideration for hacking or weaponization. *"Back in 1957, nobody thought about the fact that space might ever become crowded,"* he reflected. *"This is just a vast new ocean out there."* NASA's strategy now focuses on operating safely in low Earth orbit before expanding to lunar and Martian environments. *"What if I had a time machine and could have gone back six decades?"* Drew mused. *"What might we have done differently? Well, can we do those things differently now around places like the Moon and Mars?"*

> "We advocate for increased transparency, coordination and maintaining responsible behavior for space."

The tension between economic opportunity and environmental responsibility emerged as a central theme. Yet the path forward requires more than regulation. Drew emphasized the importance of maintaining original intent while adapting to unforeseen challenges. *"It's having the imagination to try and think about not necessarily everything that could go wrong, but how you would react,"* he explained, advocating for what he termed "skeptical optimism." Perez reinforced this with a call for collective action: *"In navigating the challenges associated with space activity, I think transparency is very important and we encourage everyone to be part of the solution."*

The session concluded with a hopeful note. Asked about youth engagement, Aschbacher described how young professionals within ESA are driving sustainability initiatives. *"It's those young people who tell me that you have to look after this,"* he said. *"The energy of young people is incredible."* Palermo shared similar observations from Australia's Kids in Space program, where finalists independently focused on space sustainability solutions. *"The youth are ahead of us in understanding the problem in many respects,"* he said.

As the Congress drew to a close, the message was clear: space sustainability cannot be addressed through isolated national efforts or voluntary commitments alone. From Philippine fishermen dodging debris to Australian astronomers losing their radio-quiet zones, from European farmers relying on crop monitoring to NASA preparing for lunar exploration, the stakes transcend any single region's priorities. The question is no longer whether to act, but whether the global community can summon the political will to transform regional concerns into collective responsibility before the opportunity to preserve space for future generations slips away. ■

IAC 2025

Highlight Lectures

Waratah Seed:
Australia's First Industry Ride-Share Satellite

> "We are developing and delivering space heritage for space companies."

In a session that felt more like a celebration than a lecture, Iver Cairns, Director of CUAVA and Professor in Space Physics at the University of Sydney, stood before an audience at the International Astronautical Congress to recount how a small team of roughly 100 people across six Australian institutions built a satellite that would win SmallSat Mission of the Year.

The Waratah Seed project represents something fundamentally different from traditional satellite missions: a deliberate effort to nurture an entire ecosystem rather than simply launch a payload. Named after the indigenous Eora word meaning *"seen from afar and beautiful,"* and honoring New South Wales' state flower, the satellite serves as both technology demonstrator and economic catalyst. "The seed is what we want to help grow: a vibrant space economy and space sector in Australia," Cairns explained.

But the mission's genesis reveals the challenges facing emerging space nations. Australia boasted a growing satellite scene but remained under resourced compared with established space powers. What Cairns and his consortium needed was a pathway to transform capability into commerce, theory into practice, and academic expertise into industrial heritage. Their answer came as a 6U CubeSat rideshare mission, designed specifically to help startups and companies gain the space heritage necessary to sell their products and compete internationally.

The payload selection process itself became a masterclass in fostering nascent space industries. Beyond the commercial payloads that provided crucial funding, Waratah Seed hosted a competition specifically targeting startups. The team worked closely with winning companies to transform working prototypes into space-qualified hardware. *"Even though there was a working prototype when they were given to us, many would not have worked in space,"* Cairns noted, describing the extensive engineering support his team provided to ensure payloads could survive launch and operate in orbit.

This nurturing approach paid dividends across multiple dimensions. Nine payloads flew aboard the satellite, including hyperspectral imaging systems, radiation monitors, GPS receivers, and experimental communications equipment. The diversity showcased Australia's growing

technical sophistication while providing companies with the operational proof points they needed to attract customers and investment. More importantly, the project trained engineers, established regulatory pathways, and demonstrated that Australia could deliver complete space missions on competitive timelines and budgets.

The engineering challenges proved substantial and occasionally surprising. Cairns described how the team simultaneously built Waratah Seed and its sibling Kuava 2, a decision he now acknowledges created unnecessary stress. The most vexing problem emerged during commissioning when Waratah Seed's attitude control system refused to cooperate despite using the same hardware as the perfectly functioning Kuava 2. *"We found out eventually that there was one subtle difference between the two ADCSs,"* Cairns revealed. *"They didn't just upgrade the ADCS, they also flipped the coordinate system for the magnetometer without telling anyone."* Once discovered, the fix was simple, but the troubleshooting consumed weeks of frustrated effort.

Regulatory hurdles demanded equal creativity. When the International Amateur Radio Union unexpectedly rejected their frequency allocation request, despite Australian approval, the team faced a choice: delay the mission or navigate commercial frequency licensing. Patrick Opel, one of the mission's key engineers present in the audience, took on the challenge himself rather than spend $100,000 on consultants. *"Patrick went ahead and did all of the analyses himself and then we submitted to the ACMA, the Australian Communications and Media Authority,"* Cairns recounted, praising both his colleague's initiative and the regulator's flexibility.

The mission's operational phase validated the team's approach while revealing the harsh realities of space business. One hyperspectral imaging payload, intended to generate revenue through earth observation data, struggled to attract customers in a market dominated by free government data sources. "The other payloads are more or less working well and providing good data," Cairns reported, acknowledging that not every experiment succeeds but emphasizing that even failures provide valuable heritage and lessons.

The broader implications of Waratah Seed extend well beyond its individual achievements. The mission established templates for payload integration, testing, and regulatory compliance that future Australian missions can follow. It proved that universities and small companies can deliver complex space systems when properly supported and coordinated. Perhaps most importantly, it demonstrated a sustainable business model where commercial payloads subsidize developmental ones, enabling more companies to gain space heritage without prohibitive costs.

Cairns outlined an ambitious vision called Waratah Space that extends this model into a regular payload pipeline to orbit. The concept envisions predictable launch cadences that companies can plan around, standardized interfaces that reduce integration complexity, and ongoing heritage development that progressively advances Australian space capabilities. *"Regular cadence, something that people can plan with and bring us to a sustainable future for space in Australia and for that matter, linking out into the wider world,"* he explained, describing a pathway from pilot project to permanent infrastructure.

The session concluded with questions that revealed both the audience's engagement and the mission's relevance to global space development. Queries ranged from specific technical challenges to broader strategic questions about payload selection, regulatory navigation, and managing multiple stakeholders with competing timelines. Cairns answered each with candor, sharing both successes and setbacks, offering a realistic picture of what building a space capability requires.

Waratah Seed proved that emerging space powers need not merely purchase capability from established providers or wait decades to develop indigenous expertise. With strategic focus, creative problem-solving, and willingness to support nascent industries through their growing pains, nations can accelerate their path from participation to leadership in space.

ADRAS-J:
First Encounter with Space Debris

In an orbit 600 kilometers above Earth, a Japanese spacecraft approached a 3-ton derelict rocket stage that had been tumbling through space for over 15 years. What happened next marked a historic first: a commercial close-up inspection of a piece of space debris, captured in images so crisp they revealed individual dents in the abandoned upper stage's nose cone. At the International Astronautical Congress, engineers from JAXA and Astroscale unveiled the results of this groundbreaking mission, demonstrating that removing the estimated 10,000 large objects threatening orbital sustainability is no longer science fiction but engineering reality.

The mission, known as ADRAS-J, represents the first phase of JAXA's Commercial Removal of Debris Demonstration (CRD2), a pioneering public-private partnership tackling one of space exploration's most vexing challenges. Toru Yamamoto, JAXA's Project Manager for the initiative, framed the stakes: *"To control the future generation of tiny space debris caused by catastrophic collisions, it is effective to remove large space debris from the crowded orbits."* The logic is compelling. Each collision between large objects creates thousands of smaller fragments, spawning a cascade that could render certain orbital regions unusable for generations.

What makes debris removal so technically daunting emerged as a central theme throughout the presentation. Unlike the International Space Station, which sports attitude control, communication systems, GPS navigation, docking mechanisms, and reflective markers, space debris is what engineers call *"non-cooperative."* Yamamoto emphasized this fundamental challenge: *"Typical non-cooperative targets like space debris do not have any of these functionalities. So that's the reason why it is very hard to even approach or capture or tow or release that space debris in orbit."*

The partnership structure itself broke new ground. Under JAXA's innovative contract model, the space agency defines service specifications and safety requirements while the private sector handles design, manufacturing, testing, operations, and business development. In return, JAXA provides technical expertise, specialized facilities, and intellectual property from years of research. The agency delivered over 200 technical advisories and developed a large-scale motion simulator enabling hardware-in-the-loop testing. Astroscale Japan won selection as JAXA's partner for both phases of the program, tasked first with inspection and later with actual debris capture and deorbit.

The target selection process was meticulous. Engineers chose an H-IIA upper stage measuring 11 meters long, representative of the large debris population posing the greatest collision risk. But approaching this target required solving a problem that has stymied debris removal efforts for decades: bridging the gap between absolute and relative navigation without cooperative markers. Chris Blackerby, Chief Operating Officer at Astroscale, described the technical choreography: *"We closed to within about 1000km relative distance between the servicer and the client. We optimized the Delta V that we had with the propulsion that we had on the servicer, using ground based SSA for the client and GPS data for the servicer."*

The mission unfolded across several critical phases, each demonstrating capabilities essential for future orbital servicing. After launch and initial orbit adjustments, ADRAS-J used angles-only navigation to close from hundreds of kilometers to just a few, then switched to onboard cameras for the final approach to 50 meters. The spacecraft carried both infrared cameras and LIDAR, generating the first detailed images of an actual piece of large debris in its natural environment.

Then came the fly-around maneuvers, perhaps the mission's most visually striking achievement. Using 12 chemical thrusters for fine control, ADRAS-J circled the tumbling rocket stage three times from different angles, capturing footage that would look at home in a science fiction film. Blackerby's enthusiasm was evident as he described watching the imagery: *"I've seen these images maybe a hundred times and they always look so cool. I love to watch it. It's incredible."* The video revealed unexpected details: the target wasn't tumbling as anticipated but remained locked pointing toward Earth, its thermal blankets beginning to deteriorate, its payload adapter ring clearly visible as a future capture point.

Yet the mission also offered sobering lessons about the complexity of on-orbit operations. During one approach, the spacecraft's computers detected an anomaly and executed an automatic abort, moving ADRAS-J 100 kilometers ahead of its target. Blackerby acknowledged this reality candidly: *"I think it's also important to recognize that of course space is difficult and that aborts happen and that anomalies happen with missions and we have to be prepared for when those anomalies do happen."* The recovery demonstrated operational resilience. Within hours, teams assessed the situation; within a week, they completed a new approach; within a month, they resumed nominal operations.

This ability to recover quickly carries implications far beyond this single mission. As orbital servicing becomes commercially viable, rapid response to anomalies will prove essential. Satellite operators increasingly need inspection and repair services that can launch and respond within days or weeks, not months. ADRAS-J proved such timelines are achievable, even for the most technically challenging operations.

"I think it's also important to recognize that of course space is difficult and that aborts happen and that anomalies happen with missions and we have to be prepared for when those anomalies do happen.

The mission's success validated years of research in angles-only navigation, infrared imaging, LIDAR systems, and proximity operations around non-cooperative objects. Engineers now possess detailed knowledge of the H-IIA upper stage's attitude, surface condition, capture points, and mechanical state. This information feeds directly into ADRAS-J2, the follow-on mission that will attempt actual capture and deorbit of the same target in the coming years.

Blackerby synthesized the mission's broader significance: *"Every one of these things, these bullets on there, from safety to cooperation to technical capability to understanding your client object.... that is what is going to make the on orbit servicing sector successful. That is what is going to make our orbits sustainable and commercially viable."* The partnership between JAXA and Astroscale demonstrated how governments and commercial entities can collaborate effectively, sharing risks and capabilities to achieve objectives neither could accomplish alone.

As the space economy expands toward projected trillions of dollars in value, the orbital environment's sustainability becomes increasingly critical. Each successful mission like ADRAS-J moves the industry closer to regular debris removal operations, satellite servicing, and orbital maintenance.

Astronomy from the Moon: :
A science cornucopia, with challenges

Martin Elvis, Senior Astrophysicist from the Harvard & Smithsonian Center for Astrophysics, delivered a Highlight Lecture exploring the Moon's potential as a platform for scientific discovery. His presentation outlined how lunar-based telescopes could answer fundamental questions about the universe, from its earliest moments to the possibility of life beyond Earth.

The concept represents a significant shift in scientific thinking. "If you haven't heard of doing astronomy from the Moon, that's not surprising, because even a few years ago, almost all astronomers, including me, thought this was a silly idea that had no value at all," Elvis said.

But as human lunar missions moved from distant concepts to near-term realities, astronomers began reconsidering what was possible. In early 2023, Elvis helped organize a meeting at the Royal Society that brought together approximately 50 astronomers from around the world. The two-day gathering revealed proposals spanning most of the electromagnetic spectrum and even gravitational waves.

The scientific opportunities span an extraordinary range. Elvis focused on five key areas where lunar observatories could make unique contributions. The first addresses the Dark Ages of the universe, before any stars or galaxies existed.

Current simulations show how the Universe transitioned from nearly uniform density to regions dense and hot enough to ignite nuclear fusion, but these models lack observational data. The key lies in hydrogen's 21-centimeter emission line. While useful for mapping local galactic structure, observing the Dark Ages requires detecting radiation stretched by cosmic expansion to wavelengths 100 times longer, placing it in a frequency range difficult to observe from Earth.

The search for extraterrestrial life represents another compelling application. Identifying which Earth-sized planets in habitable zones possess magnetic fields would help scientists focus on promising candidates. Lunar-based radio telescopes could detect planetary aurorae, revealing protective magnetic fields. Elvis noted that such observations could extend to detecting technosignatures out to 100 light years from Earth.

Understanding supernovae represents a third opportunity. After 50 years of failed computer modeling, scientists only recently developed simulations showing how these stellar deaths occur. The key lies in observing gravitational waves from within the star as it explodes, revealing the core's collapse and rebound in real time. These waves fall in a frequency range that ground-based detectors cannot access, but lunar instruments could.

The Moon offers several advantages. Its far side provides complete radio silence from Earth's interference. The lack of atmosphere eliminates distortion affecting ground-based telescopes. Certain locations reach temperatures

as low as 25 Kelvin, ideal for infrared observations. Some sites remain in permanent sunlight, providing constant power, while permanently shadowed regions offer natural cryogenic environments.

Elvis outlined several specific concepts. A far infrared telescope could detect the first stars forming after the Big Bang, observing wavelengths that Earth's atmosphere blocks. A gravitational wave detector would consist of three satellites orbiting the Moon, measuring surface movements with nanometer precision. An optical interferometer array could eventually image Earth-sized planets around nearby stars, though this capability lies decades in the future.

The most ambitious proposal involves a very low frequency radio telescope on the far side, consisting of thousands of dipole antennas spread over hundreds of square kilometers, operating at frequencies between 1 and 50 megahertz. This range cannot be observed from Earth due to radio emissions and atmospheric interference, yet it contains crucial information about the Dark Ages and potentially about magnetic fields on distant planets.

These projects face substantial challenges. Operating in permanently shadowed regions where temperatures can reach minus 250 degrees Celsius presents construction difficulties. But the most significant challenge extends beyond engineering. Multiple astronomical projects will compete for the same small areas of the lunar surface. The South Pole region spans only a few kilometers. The far side's radio-quiet zone similarly occupies a limited area. "Even though something may be 50 years away before we can do it, we still need to pin down the best locations where we'd like to put that so that we can keep that location in pristine condition", Elvis emphasized.

The governance challenge lies in protecting these sites for future scientific use while development and resource extraction proceed. No current framework exists for designating and maintaining scientific reserves on the Moon. Commercial interests, national programs, and scientific needs will increasingly conflict over access to prime locations.

Elvis projected that preliminary investigations would determine feasibility within a decade, with full implementation requiring another 10 years minimum, placing these capabilities roughly 20 to 30 years in the future. Once operational, these facilities would exceed existing telescopes by orders of magnitude. The collaboration models remain unclear, though such projects typically evolve into international partnerships.

The lecture revealed how advancing computer simulation capabilities have created a gap between theoretical models and observational confirmation. The Moon offers the rare combination of location, environment, and accessibility needed to gather the data these models require.

Elvis addressed the broader question of lunar development by noting that the Moon's estimated billion tons of water could support a scientific base of a thousand people for several millennia, but a settlement of 100,000 people would exhaust this resource in roughly a century.

The path forward requires balancing multiple interests on a body where valuable real estate occupies tiny areas. While the technical challenges remain substantial, the governance questions surrounding who decide how the Moon's most scientifically valuable locations will be used may prove more difficult to solve. As human presence on the Moon expands, these decisions become increasingly urgent.■

> "The cultural geography of the Moon is something we will be setting in this generation. And let us hope that we set a good example that will persist for a century to come or more, because, if we get it right, we will understand the universe and our place within it and we'll be the better for it.""

Late Breaking News 1
Dual Frequencies, Single Purpose, For a Resilient Earth

In a demonstration of what international partnership can achieve when nations set aside boundaries, the NASA-ISRO Synthetic Aperture Radar (NISAR) mission reached a critical milestone this year. On July 30, 2025, India's GSLV (Geosynchronous Satellite Launch Vehicle) carried NISAR into sun-synchronous orbit, marking not just another satellite deployment but the culmination of a decade-long collaboration between two space powers united by a single purpose: understanding our changing planet at an unprecedented level of detail.

The mission represents a technical marvel, but more than that, it stands as testament to what V. Narayanan, ISRO's chairman, called *"the teamwork exhibited together."* His words carried weight beyond typical diplomatic pleasantries. For ten years, engineers from Bengaluru to Pasadena worked through design challenges, a global pandemic, and the inherent complications of building a spacecraft across continents. They emerged with a satellite carrying two sophisticated radar instruments capable of mapping the entire Earth every 12 days with resolution so fine it can detect ground movement of just centimeters.

Technical achievement becomes clear in the numbers. ISRO's GSLV launcher, on its 102nd flight and 18th GSLV mission, placed the 2,400-kilogram satellite into an orbit 747 kilometers above Earth with remarkable precision. The target orbit had a tolerance of plus or minus 20 kilometers. The actual injection achieved 2.5 kilometers from nominal, a precision that drew appreciative murmurs from the audience of space professionals. This accuracy mattered because NISAR's mission demands exacting orbital parameters to enable its primary capability: detecting change on Earth's surface through repeated observations of the same locations.

At the heart of NISAR's capabilities sit two radar instruments working in tandem. NASA's Jet Propulsion Laboratory developed the L-band synthetic aperture radar with its 12-meter deployable antenna, while ISRO's Space Applications Centre created the S-band instrument. Together, they provide complementary views of Earth's surface, with the L-band penetrating vegetation canopy and the S-band offering detailed surface mapping. Narayanan emphasized the anxiety surrounding one particular moment: *"The antenna was deployed on August*

14, and antenna deployment, please understand one thing, it was a single point failure. It was a very exciting day when the antenna was perfectly deployed on the 15th of August. It was also a tense moment."

That tension was justified. The 12-meter antenna, the largest radar antenna ever deployed in space, had been tested on the ground in the United States before integration. But once mounted to the satellite, there would be no second chances. Its successful deployment cleared the path for the mission's next phase: calibration and validation.

Karen St. Germain, Director of NASA's Earth Science Division, shared the first results with barely contained enthusiasm. The images revealed capabilities that exceeded even optimistic predictions. Over Mount Desert Island off Maine's coast, NISAR captured detail across its 240-kilometer swath width while maintaining five-meter resolution. *"When you zoom in, you're seeing spatial resolution that is on the order of 5 meters,"* St. Germain explained, describing how the false-color imagery distinguished rocky outcrops from forested areas with clarity unavailable to optical sensors.

But the real revelation came from North Dakota farmland, where NISAR's radar penetrated beyond surface appearances. In optical imagery, agricultural fields appeared uniform. The radar backscatter revealed hidden structure: tall corn stood distinct from shorter soybeans, wetlands meandered along a river invisible in visual wavelengths, and center-pivot irrigation systems etched perfect circles across the landscape. *"Features pop out in the radar image that weren't visible in the optical imagery,"* St. Germain noted, highlighting how radar's ability to sense structure rather than just color opens new dimensions of Earth observation.

Yet NISAR's most powerful capability remained to be fully demonstrated. The mission's interferometric mode, which measures ground deformation by comparing observations taken days apart, had already produced its first results. Though still uncalibrated, the initial interferogram showed the phase stability needed to detect surface changes of a centimeter or less. This precision matters for tracking everything from volcanic deformation to glacier movement to land subsidence. *"This demonstrates the phase stability of the radar that is going to give us that very precise imagery of change in the surface of the Earth,"* St. Germain said, describing the interferogram as coming *"almost right out of the box."*

The mission's approach to data democratization breaks new ground in Earth observation. Within 90 days of launch, all NISAR data will become freely available to researchers and operational users worldwide. No restrictions, no fees, no proprietary access periods. Some 180 organizations have already prepared to use the data stream for applications ranging from disaster response to agricultural monitoring. St. Germain warned the audience to prepare for the scale: *"This mission is going to produce 80 terabytes of data per day, and that's for quite some number of years. This mission will double the entirety of our holdings of Earth science data at NASA that we've collected for 60 years."*

"This mission is going to produce 80 terabytes of data per day, and that's for quite some number of years. This mission will double the entirety of our holdings of Earth science data at NASA that we've collected for 60 years."

The partnership model that enabled NISAR offers lessons beyond this single mission. Both speakers emphasized how working through challenges, from technical hurdles to COVID-19 disruptions, strengthened the collaboration. Narayanan pointed to *"outstanding work"* from both teams, while St. Germain described being *"thrilled with the partnership"* despite real challenges along the way. Their mutual emphasis on teamwork over individual achievement suggested that successful international missions require more than just dividing responsibilities. They demand genuine partnership built on shared goals and mutual respect.

As the calibration phase continues through its final weeks, NISAR stands ready to transform Earth observation. Its combination of wide coverage, fine resolution, day-night operation, and weather independence creates capabilities no single-frequency radar can match. The dual-frequency approach allows scientists to separate surface changes from atmospheric effects while providing complementary information about Earth's surface and subsurface processes.

The mission's free and open data policy ensures these capabilities benefit everyone. From developed nations tracking infrastructure stability to developing countries monitoring crop health, NISAR's observations will enable what St. Germain called *"smarter decisions where people need to make them, when they need to make them around the world."* In an era of rapid environmental change, such capabilities become not just scientifically valuable but operationally essential. As both speakers made clear, NISAR represents more than technical achievement. It demonstrates what becomes possible when nations work together toward understanding and protecting our shared home.

Late Breaking News 2:
Launching Australia's First Orbital Rocket – Lessons Learnt

In a nation that began its space journey without a space agency and under regulations that almost prohibited launches, Australia achieved a historic milestone this year with its first orbital rocket attempt. At IAC 2025's Late Breaking News session, Adam Gilmour, CEO and Co-Founder of Gilmour Space Technologies, delivered a remarkably candid account of the technical challenges, financial realities, and hard-won lessons from building a rocket company from scratch. His presentation revealed not just the story of one launch attempt, but the decade-long journey of transforming a 140-square-meter factory on Queensland's Gold Coast into Australia's first orbital launch capability

The path to the pad was anything but straightforward. When Gilmour attended a NASA meeting at Kennedy Space Center early in the company's history, he found himself sitting next to someone from SpaceX. NASA had gathered rocket companies with one pointed message: nobody in the new space industry had launched a rocket yet. *"I went back and said, right, guys, we've got to put a rocket together and we've got to launch one so we can differentiate ourselves,"* Gilmour recalled. That first hybrid rocket launch became the company's calling card, helping secure investment from Australia's largest venture capital firm at a time when the country had no launch infrastructure whatsoever.

The technical lessons began accumulating immediately. During an early suborbital test in Australia's remote interior, a seemingly minor decision led to catastrophic failure. A pressure sensor connection, routed through a flight computer instead of directly to the regulator as specified in the instruction manual, added mere hundredths of a second to the response time. That minuscule delay proved fatal, preventing a valve from closing quickly enough during an overpressure event. *"This was a suborbital flight of at least the first half of it,"* Gilmour joked, distilling the failure into a lesson he would repeat throughout the session: test like you fly.

This principle of testing exactly as you intend to operate became a recurring theme as Gilmour detailed the company's progression from small hybrid rockets to orbital vehicles. The approach required strategic thinking about resource allocation. *"One of the things that I thought about when I was starting the space company, as I'd done research on other rocket companies and they spend forever building their rocket engines,"* he explained. His solution was to focus intensively on propulsion first, then expand the team only after achieving reliable engines. This methodical approach helped the company reach the pad *"with a lot less money than a lot of our competitors, particularly in the United States."*

The challenge of building Australia's first orbital launch site emerged as both a technical and entrepreneurial adventure. With no government launch facilities forthcoming, Gilmour gave his co-founding brother a simple mission: find a location in North Queensland. What they discovered was a cow paddock within a secure Queensland government development area. *"A lot of the media said the Gilmours launched a rocket in a cow paddock. And I*

> "It is very important, in space industry, to understand failure, and learn from failure."

got really offended by that," Gilmour admitted. *"But then you go down to the launch site and you do see cows. So, I was like, 'okay, they're calling it as they see it,' as we say in Australia."* In just two and a half years, that pastoral setting transformed into Australia's first space agency approved orbital launch site, complete with vehicle assembly building, fluid systems, launch tower, and all the infrastructure of a proper spaceport.

The financial realities of rocket development dominated much of Gilmour's narrative. Coming from 20 years in financial markets before becoming, in his words, *"a rocket dude,"* he brought an unusual perspective to the traditionally engineering-focused industry. "If you don't focus on the money, you can spend a lot on rockets," he noted. This financial discipline manifested in constant cost-benefit analysis: *"Does that million-dollar test get us enough information that we need or not? Is there another way to do that?"* The approach paid off, but not without the continuous challenge of raising capital through multiple funding rounds.

When discussing the actual launch attempt and its failure, Gilmour demonstrated the importance of managing expectations. The company had carefully educated investors that success on the first attempt was unlikely. "The average of every rocket company that's gone to orbit is three launch attempts before they get to orbit. The mightiest of all, SpaceX took four," he explained. This preparation meant investors understood that getting off the pad, even in failure, represented a significant achievement. In the Western world's commercial space sector, *"there's only six companies that are still alive today that have gotten a rocket off the pad and that includes SpaceX."*

The technical post-mortem revealed valuable lessons about rapid iteration. When the payload fairing separated prematurely, the team conducted an internal investigation, identified the problem, implemented a fix, tested it, and prepared to fly again within the same launch window. *"You don't have to abandon the launch attempt,"* Gilmour explained. *"As long as you can identify the problem, fix it, test it, you can fly again. And that's what all the other rocket companies do around the world."*

Perhaps most striking was Gilmour's emphasis on failure as a learning tool when addressing questions about preparing young professionals. *"The most important thing you can do is build things, test them, fail, learn from failings, fix it and see success,"* he said. *"We don't really care if it's a rocket engine or it's a car or a drone. It's very important in the space industry to understand failure and to learn from failure."*

The session concluded with Gilmour's optimistic vision for Australia's space future. With regulations now in place, operational launch facilities established, and multiple satellite companies thriving, he projects substantial growth. *"In the next five years you're going to see more launches out of Australia. You may see other rocket companies come here and launch as well. A lot more satellites go up,"* he predicted. When asked why he chose to build in Australia, his answer was simple but emphatic: *"We got everything we need in this country to go to orbit. And we will as a nation, we'll go to orbit, and we'll go further than orbit."* ■

IAC 2025

IAF Global Networking Forum (IAF GNF)

Global Networking Forum
Meet. Share. Connect.

Monday
29 September 2025

In the opening Global Networking Forum sessions of the 2025 International Astronautical Congress, space leaders gathered in Sydney to explore three interconnected challenges shaping humanity's cosmic future: building long-term strategic vision, harnessing artificial intelligence to revolutionize space operations, and transforming ocean intelligence through satellite data. The discussions revealed a space sector grappling with how to make its capabilities more accessible, efficient, and responsive to urgent terrestrial needs, particularly for vulnerable communities across the Indo-Pacific region.

The morning began with **"ESA Strategy 2040: The Process of Defining ESA's Vision for Europe in Space"**, a roadmap born from two years of intensive consultation across 23 member states. Heriberto Saldivar, Head of Strategy at the European Space Agency, opened with a compelling reminder of space's importance to modern life: *"Space is woven into the fabric of our daily lives. When farmers decide to irrigate or harvest, they rely on satellites measuring the soil, predicting the rainfall."* Yet the challenge facing European space was stark. McKinsey projections estimate the space market will reach $1.8 trillion by 2035, but the United States alone invests more than half of global public funding, while China and India expand rapidly. For Europe, maintaining relevance requires embracing what many see as an obstacle: its extraordinary diversity.

ESA's approach to building Strategy 2040 transformed this diversity into strength. With 23 member states representing different histories, industries, and political priorities, plus 11 directorates spanning the full spectrum of space activities, the organization faced a complex coordination challenge. *"Every directorate contributes, every member state has the chance to shape the outcome through consultations and workshops,"* Saldivar explained. A pivotal moment came when younger staff members stood up during planning sessions to assert their stake in the future. *"If this is about 2040, then it's about us because we will have to deliver it,"* he said, fundamentally shifting the process from top-down mandate to collaborative co-creation.

The resulting strategy centers on five interdependent goals: protecting Earth and climate across three layers (from surface ecosystems to orbital debris to planetary defense), exploring and discovering through both scientific missions and human spaceflight, strengthening European autonomy and resilience, fostering a thriving space economy, and inspiring people.

The second session, **"Leveraging AI and Emerging Technologies to Drive Innovation and Economic Impact in Space"** shifted focus to artificial intelligence as the foundation of future space operations. Fatima Al Shamsi, Director of Space Policies and International Relations Department at the UAE Space Agency and session moderator, framed the discussion around the central idea that *"AI is not just a tool, it is a strategic priority. We are embedding AI into the very fabric of our national space program."* The panel featured leaders from Mohammed Bin Rashid Space Center, Edge Group's FADA entity, and the Technology Innovation Institute's Propulsion and Space Research Center, showcasing the UAE's integrated approach to space development.

Salem AlMarri, Director General of Mohammed Bin Rashid Space Center, outlined how AI is transforming satellite data utilization. *"A lot of our data is used for town planning, environment, and other applications,"* he explained. *"When we bring AI and machine learning to help support us, it could be in space where we're analyzing that data and downloading what's useful. So we're more efficient in downloading the data that we require, or on the ground where we're able to get an image quickly, analyze it, get the data that we require and give it to our customers within minutes rather than hours or days."* The center is also leveraging AI for satellite design optimization, using advanced 3D printers that employ AI algorithms to create the most efficient component designs before manufacturing.

Mohammed Al Ahbabi, Senior Advisor at Edge Group, introduced Tactica, an AI tool developed jointly with the Technology Innovation Institute that allows users to interact with Earth observation data conversationally. *"The end user or the user can talk to it, as when you talk to ChatGPT, to give you information about a location,"* he explained. The tool can provide alerts when abnormal activities occur in monitored locations, demonstrating how AI bridges the gap between raw data and actionable intelligence.

The discussion turned philosophical when addressing accountability for AI decisions in space operations. *"It's going to be hard, but I think with the AI itself and other measures, probably we can find the solution,"* Al Ahbabi said. When asked to choose between reliability and speed for AI applications, the consensus favored reliability for space operations, though tempered with pragmatism about cost constraints.

The final Monday session, **"Ocean Intelligence using Space Data"**, brought the discussion back to Earth, focusing on ocean intelligence and its critical importance for Indo-Pacific communities. The moderator painted a vivid picture: *"Imagine a small fishing village here in the Indo-Pacific. The ocean is their lifeline. But in recent years, waters have gotten warmer, storms are more unpredictable, and fish are harder to find."* Satellites can trace shifting currents, track illegal vessels, and spot early signs of coral bleaching, but as the moderator emphasized, *"intelligence, in my view, is worthless unless we complement it with in situ knowledge and unless we equip those who need it most with the ability to use it."*

Madin Maseeh, Founder & President of the Maldives Space Research Organization, delivered the session's most powerful testimony. The Maldives operates the world's most sustainable fisheries sector through traditional pole-and-line fishing, but climate change has disrupted the indigenous knowledge passed down through generations. *"One of the issues with climate change is that it has disrupted the weather systems, disrupted the oceans within the Maldives, which is 99% of our territory,"* Masey explained. *"This means that now the fishermen cannot rely on the indigenous past knowledge of where the fish are and their movements."* For Maldivian fishermen, time literally equals money and fuel. Higher frequency sea surface temperature data could help them avoid areas where tuna won't be, saving precious resources. Yet Masey's wish at the session's end cut to the heart of a broader problem: "I wish that the space sector and the ocean sector would talk more. We've seen a lot of solutions created on coral reefs, on the oceans, where when we ask, 'So who from the Maldives did you work with to validate this?' And they're like, 'No one. This should work.' And we show them exactly why and where it doesn't work."

Dawn McIntosh, Director of Space Systems at Fugro Australia, addressed the technical challenge of reducing time lags between data acquisition and actionable insights. Five years ago, obtaining ocean data could take days; now, companies like LatConnect 60 and Fugro's EOMAP are working to bring that down to hours. But as Christian Hauglie-Hanssen, Director General of the Norwegian Space Agency emphasized, success requires viewing the entire value chain, from data acquisition through distribution to end users, preferably in near real-time conditions.

Atsushi Takata, Executive Vice President for Global Strategy and Space Utilization at Space Data Inc., highlighted the growing importance of data fusion, combining RF, SAR, optical, and hyperspectral data to enable better decisions. When asked about his wish for advancing ocean intelligence, he struck at a fundamental barrier: *"Space is supposed to have no boundaries. But when I'm in this industry, I can feel a lot of the boundaries."* He envisioned a future where each nation works together to solve shared challenges, uniting both private and public knowledge.

The Monday sessions revealed a space sector at a crossroads. ESA's Strategy 2040 demonstrates how long-term planning can unite diverse stakeholders around shared goals. The AI discussion showed how emerging technologies promise to transform space operations from data collection into rapid intelligence delivery. Yet the ocean intelligence session exposed a critical gap: sophisticated space capabilities remain disconnected from the communities most in need. The challenge ahead is not just collecting more data or processing it faster but ensuring it reaches those who can act on it, presented in forms they can use, validated through genuine partnerships. In the Indo-Pacific and beyond, closing this gap may determine whether space technology fulfills its promise of serving all humanity.

Tuesday
30 September 2025

Tuesday's six Global Networking Forum sessions revealed a space sector grappling with transformation on multiple fronts. From artificial intelligence ethics to spectrum coordination, commercial space station development to space food innovation, the discussions highlighted how rapidly evolving technologies and business models are forcing industry to rethink fundamental assumptions about governance, sustainability, and human presence in space.

The first session of the day, **"From LEO to Lunar: Delivering Sustainable Innovation in Space"**, focus on the spectrum of management and regulatory frameworks. Moderated by Audrey L. Allison, Senior Project Leader of Center for Space Policy and Strategy at The Aerospace Corporation, the session featured: Kevin Coggins, Deputy Associate Administrator and Program Manager for Space Communications and Navigation at NASA; Jorge Ciccorossi, Head of the Space Strategy and Sustainability Division at ITU (International Telecommunications Union); Josef Koller, Head of Space Safety and Sustainability at Amazon Kuiper; Zhang Peng, General Manager of Solution Department at GalaxySpace; and David Goldman, Vice President of Satellite Policy at SpaceX, who examined how international coordination mechanisms are struggling to keep pace with explosive growth in satellite constellations.

The discussion laid bare fundamental tensions between innovation speed and regulatory cycles. Goldman articulated the frustration felt by rapidly growing operators. He highlighted SpaceX's direct-to-device system as an example where the ITU's "do no harm" rule enabled life-saving emergency communications during natural disasters, operating successfully precisely because traditional regulatory processes would have been too slow. *"That is a safety of life rule that is critical for new innovation,"* Goldman emphasized, warning against efforts to curtail this flexibility.

Ciccorossi defended the ITU's deliberative approach, noting that quick decisions without thorough study risk creating frameworks that become obsolete or favor certain operators unfairly. The discussion revealed deeper questions about how international bodies can balance the needs of established geostationary operators, emerging mega-constellation providers, and developing nations seeking space access. Koller and Peng both described their companies' extensive coordination efforts, from pre-launch spectrum permissions to real-time collision avoidance systems, demonstrating that responsible operators are already implementing sustainable practices even as regulatory frameworks evolve.

The day followed with a session **"AI Governance: Defining an Ethical Framework for Driving the Future Space Economy"**, where panelists explored how artificial intelligence is already reshaping space operations while raising urgent questions about regulation and oversight. Moderated by Christopher Geiger, Internal Audit and Enterprise Risk Vice President for Lockheed Martin, the session brought together Bruce Chesley, Senior Associate with Teaching Science and Technology, Inc (TSTI); Kat Coderre, Deputy Manager for Lockheed Martin's Deep Space Exploration Advanced Programs; Maria Antonietta Perino, Director of Thales Alenia Space's Space Economy Exploration International Network; Angelo Iasiello, Executive Vice President of Operations & Strategy Office at the at the American Institute of Aeronautics and Astronautics (AIAA); and Shaun Wilson, Founder and CEO of SHOAL Group.

The conversation revealed AI's pervasive presence across space operations. Coderre described how Lockheed Martin's/NASA OSIRIS-REx spacecraft used natural feature tracking and digital twins to successfully collect asteroid samples, demonstrating AI's role in enabling missions previously limited by computational constraints. Perino emphasized AI's growing importance in debris mitigation, where autonomous systems must rapidly process sensor data to identify targets for refueling or repair missions. The democratizing effect of AI emerged as a central theme, with Wilson observing that *"tasks that used to require lots of on the ground computation, lots of people, large spacecraft, can now be done with AI assistance at a much lower price and complexity point."*

Yet the panel's most provocative exchanges centered on governance challenges. Iasiello warned that *"the increasingly pervasive use of the technology of AI in space ultimately will outpace the ethical frameworks that need to be built around it."* When pressed on when humans should trust AI versus relying on their own judgment, Perino offered a refreshing personal perspective: "I never use AI. I live in a family with two nerds, both my husband and my son, and they use AI every day. I don't." Her point was clear: there's no universal formula for AI adoption. Different team members will leverage AI for different tasks, from structural analysis to thermal verification, but collective human judgment must remain paramount in critical decisions.

The IAF GNF session **"Station to Table: Perspectives on Space Food"**, moderated by Vast's Lead Astronaut Andrew Feustel, filled the room to the brim. The panel brought together Flávia Fayet-Moore, Founder and CEO of FoodiQ Global; Ralph Fritsche, Strategy and Development Lead at Deep Space Food Challenge; Zack Rosenthal, Space Food Systems Manager at Vast; Dalia David, Chef and Co-founder of Heritage Space Food; and Jacob Scoccimerra, Space Program Lead for Interstellar Lab.

Fayet-Moore opened with sobering realities about nutritional challenges. Astronauts in low Earth orbit require double the protein intake of Earth-bound individuals and vastly elevated vitamin C and D levels to counteract muscle loss, bone degradation, and immune system stress. *"On Mars we just don't have data of what are the nutritional changes that will happen for those long duration missions beyond one year,"* she noted, identifying a critical gap for future exploration. When Feustel asked about real-time blood chemistry monitoring, Fayet-Moore's response underscored the intersection of space and terrestrial health: *"If we can leverage that space technology, we can help identify the nutritional status of people around the globe as well, not just space."*

The discussion of bioregenerative systems revealed both promise and complexity. Scoccimerra described Interstellar Lab's Deep Space Food Challenge winning system incorporating microgreens, fungi, and black soldier flies to minimize waste.

Fritsche provided historical perspective, noting how space serves as an ideal testbed for sustainable food practices with direct Earth applications. *"By the year 2050, we're looking to feed maybe 10 people on the surface of the Moon, but here on Earth, we're looking to feed 10 billion people,"* he observed. *"And how do I leverage both of those to the maximum extent possible?"* Rosenthal concluded by emphasizing food's unique power to make space missions relatable: *"When I tell people I work at Vast, before they even know what I do, the first thing they say is, oh, what are the astronauts going to eat?'"*

The afternoon's fourth session, **"ISS to Starlab: The Future of Commercial Space Stations and Global Policy"**, explored the looming transition from the International Space Station to commercial platforms. Moderated by Eric Stallmer, Executive Vice President for Government Affairs and Public Policy for Voyager Space Holdings, the panel featured Marshall Smith, CEO of Starlab; Issei Shinohara Vice President & General Manager of Aerospace Department at Mitsubishi International Corporation; and John Horack, Professor and Neil Armstrong Chair in Aerospace Polity from Ohio State University, examining how commercial stations will reshape access to low Earth orbit research and manufacturing.

Smith presented an ambitious vision extending far beyond traditional space station concepts. *"When I think about Starlab, I think of it as more than a space station. It's kind of a vision,"* he explained, describing plans for a facility enabling

proprietary pharmaceutical research, semiconductor development, and organ transplant advances. The station's dramatically larger habitable volume compared to ISS modules reflects new launch capabilities, allowing nearly all maintenance to occur internally rather than through risky spacewalks.

Shinohara outlined Mitsubishi's dual role: engaging Japanese stakeholders in post-ISS strategy development and creating commercial demand beyond traditional one-off experiments. His frank acknowledgment that *"it sounds very challenging"* captured the session's underlying tension between technological capability and market development. Horack emphasized the need to reduce friction in space research, noting that ground-based laboratories allow scientists to adjust experiments multiple times daily, a flexibility current space operations rarely provide. *"We need to make sure that we're paying attention to things that you can put on the outside as well as the inside because both of them are unique laboratories,"* he observed, critiquing ISS's engineer-focused design for missing research opportunities.

"The Role of Space for South Africa's Resilience" session offered a condensed but powerful vision of how one nation views space as fundamental infrastructure rather than luxury. Speaker Humbulani Mudau, CEO of the South African National Space Agency (SANSA) outlined six interconnected themes driving the country's space program: security, sovereignty, and independence; space applications for decision-making; economic growth and job creation; good governance and multilateralism; human capital development; and space diplomacy.

Mudau emphasized that South Africa's approach centers on building capabilities that directly serve national needs while fostering African continental development. *"We believe that space has a huge role to play in ensuring that we do so. Space is not just a luxury, it is a necessity for sovereignty and independence as well as building a safer and more prosperous nation,"* he stated. The presentation highlighted South Africa's geographic advantages, including hosting the Square Kilometer Array radio astronomy project and offering a radio quiet zone that positions the nation as an essential partner in global space science.

In the final session of the day, **"Unlocking the Commercial Potential for Space-Enabled Healthcare"**, moderator Paul Bate, Chief Executive Officer of the UK Space Agency, challenged the panel to break through what he called *"fictitious barriers"* between space and healthcare sectors. The discussion ranged from satellite-enabled telemedicine serving remote regions to microgravity pharmaceutical research accelerating drug development, with panelists from industry, venture capital, and government agencies bringing markedly different perspectives.

Brooke Mills, CEO of Astraea Technologies, framed the conversation around human-centric space business. *"We need to talk about humans. What are we doing to the humans that are going up there? What are they experiencing on a daily basis from a physical perspective, from a mental health perspective,"* she asked, emphasizing that healthcare challenges in space often translate directly into terrestrial applications.

The commercial reality check came from Sanjeev Gordhan, General Partner at Type one Ventures, whose firm manages $1.5 billion across space-adjacent technologies. Gordhan described working with companies developing better insulin formulations in microgravity, seeing immediate terrestrial market potential, and the same time highlighting the gap between space sector innovation and pharmaceutical industry engagement.

James Waldie, Co-founder and CEO of Cape Bionics and Co-founder of Human Aerospace provided concrete examples of dual-use technology, describing how compression garments developed as space countermeasures for bone health and fluid shifts evolved into Cape Bionics, enabling doctors to easily scan and prescribe custom-fit therapeutic garments. The regulatory challenge emerged as a persistent theme, with panelists noting that innovation often migrates to jurisdictions offering faster approval pathways.

Bob Lamboray, Lead for Exploration and Space Resources at Luxembourg Space Agency captured the session's fundamental message: *"It should not be about space, it should be about what you can do in space. The majority of people do not really care about the space industry, but they care about healthcare. So, if there is a clear product or benefit of doing this in space, then they will get interested."*

Tuesday sessions painted a portrait of an industry at an inflection point. Whether discussing AI's expanding capabilities, spectrum coordination challenges, commercial station development, or food system innovation, panelists consistently returned to themes of sustainability, accessibility, and the tension between rapid innovation and thoughtful governance. The discussions made clear that succeeding in space's next chapter will require not just technical breakthroughs but fundamental rethinking of how international cooperation, commercial development, and human factors intersect to shape humanity's future beyond Earth.

Wednesday
1 October 2025

On Wednesday, five IAF Global Networking Forum sessions at the 2025 International Astronautical Congress tackled critical challenges facing the space sector, from orbital sustainability and investment strategies to India's rapidly expanding space ecosystem and challenges for s[ace systems architecture. The sessions revealed a space community grappling with urgent questions about long-term viability, commercial growth, and the fundamental competencies needed to realize ambitious exploration goals.

The day opened with **"International Collaboration Towards Safe and Sustainable Space Traffic"**, where Renato Krpoun, Head of the Swiss Space Office (SSO), painted a sobering picture of orbital congestion. Standing before images of the University of Bern's Zimmerwald Observatory, where optical space debris research has tracked fragments for decades, Krpoun warned that space is approaching a critical threshold. *"We're on track to see up to 100,000 active satellites in orbit within the next decade,"* he stated, noting that tracking systems already monitor over 54,000 objects larger than 10 centimeters while millions of smaller fragments pose undetectable but serious risks to missions.

The session's centerpiece was a stark example: an image of ESA's Sentinel 1 satellite, its solar panel punctured by a millimeter-sized object in 2016. *"Imagine a 1-centimeter object hitting the solar panels. What size and what damage could have happened,"* Krpoun emphasized. This visual underscored the panel's central argument that space has become what he called a *"tragedy of the commons,"* requiring unprecedented international cooperation to avoid catastrophic cascading collisions.

Thomas Schildknecht, Professor Emeritus at Astronomical Institute at the University of Bern, who has operated the Zimmerwald Observatory for many years, stressed the cultural dimensions of space traffic management during the expert discussion. *"We have to recognize different cultures. The best practice we have in technical practice in Europe is not the same as in the US and it's by far not the same as the Russians or the Chinese are applying,"* he noted. The panel, moderated by IAF President Clay Mowry and including representatives from the UAE Space Agency, legal experts, and industry leaders, highlighted the newly formed UN COPUOS Expert Group on Space Traffic Coordination as a promising starting point for global dialogue, though participants acknowledged that binding agreements remain distant goals.

The session's emotional undertone was captured when Switzerland announced its bid to host IAC 2029 in Geneva, positioning the city's concentration of 180 international organizations and tradition of neutrality as ideal for advancing space traffic coordination. *"Geneva is unique in the world. A city where science, policy, and diplomacy live side by side,"* said Raoul Keller, Secretary General of the Swiss Space Industry Association and Swissmem.

"Unlocking India's Space Potential: A Global Dialogue on Reforms and Partnerships" showcased the dramatic transformation of India's space sector following government reforms three years earlier. Pawan Goenka, Chairman of IN-SPACe, the regulatory body created to enable private sector participation, traced the evolution from ISRO's government-dominated era to a dynamic ecosystem with 300-350 new companies. *"All that has been possible because of the space reforms that were launched about four years ago,"* Goenka explained, detailing how IN-SPACe serves the dual role of promoter and regulator, an experiment he acknowledged as *"somewhat confusing"* but *"working reasonably well."*

ISRO Chairman V. Narayanan outlined the agency's ambitious future, including eight approved Gaganyaan missions beyond the original three, lunar landing plans by 2040, and a space station under development. His presentation emphasized inclusivity in these programs. *"The entire vehicle buildup realization and orbital module realization and all the hardware realization is happening only in the private sector,"* he stressed, describing unprecedented opportunities for companies to participate in human spaceflight programs.

The international partnership dimension was highlighted by Enrico Palermo, Head of the Australian Space Agency, who described three years of collaboration that has produced dozens of memorandums of understanding between Indian and Australian companies. IAF President Clay Mowry reinforced India's growing global influence, noting that international partnerships must recognize India's transformation from purely scientific missions to commercial space leadership.

Narayanan delivered perhaps the session's most memorable advice to companies hesitant about entering space business: *"If somebody has to enjoy swimming, you have to jump inside water. Standing outside doing studying whether swimming will happen, this will happen, you will be only standing outside. Please jump inside. You will enjoy it. You will succeed."*

The third session, *"Success in Space Through Security, Investment, and Sustainability"*, brought together task force leaders who had spent three years developing IAF President Clay Mowry's signature initiative. Mowry opened by explaining how these three themes emerged from listening at the Dubai IAC four years earlier. *"You can't have investment in space if you don't have a sustainable place to invest and a secure environment to operate,"* he declared, framing the interconnected challenges facing a sector that has seen a tenfold increase in operational satellites and billions in private capital over the past five years.

The discussion revealed tensions between traditional space sector thinking and emerging commercial realities. Agnieszka Łukaszczyk, Founder and CEO of hiALtitude Consulting, emphasized the communication gap that has long plagued the industry. *"We have a tendency to talk to ourselves rather than talk to people outside,"* she observed, highlighting the struggle to connect space technology's obvious benefits to climate monitoring and biodiversity with broader public understanding.

Victoria Samson, Chief Director, Space Security and Stability for Secure World Foundation, brought urgency to the conversation by noting the growing militarization of space and the need to bring military space organizations into truly international discussions. *"Looking ahead to figure out ways in which to make it acceptable for military space folks to come here and get them involved in the conversation,"* she said, acknowledging that such forums currently exist only in limited, US-centric venues.

The investment challenge proved particularly thorny. Carissa Bryce Christensen, Chief Executive Officer and founder of BryceTech, drew sharp distinctions between reaching venture capital investors already engaged with space and attracting private equity firms that could scale successful startups. *"When you have a bunch of venture capital in a bunch of startup companies, the hope is some of those companies will grow rapidly and successfully and attract investment, private equity investment at a larger scale,"* she explained, noting that space generally hasn't reached that point, with exceptions increasingly tied to national security expenditure.

Missing session **Earth Observation for Pacific Disaster Resilience: Synergizing Industry, Government, and NGOs**

In the IAF GNF session **"Systems Architecture and Realization: Key Success Competencies"**, industry veterans gathered to address what session moderator Heinz Stoewer, CEO of Space Associates, characterized as a looming workforce crisis. *"The problem is there is not sufficient supply of experienced system engineers, system architects,"* Stoewer warned, framing the discussion around a stark question: What do mobile phones, tractors, washing machines, aircraft, and satellites have in common?

The answer, explained through presentations from academia and industry, lies in their evolution into complex, software-defined systems requiring multidisciplinary expertise that universities struggle to teach and industry struggles to develop. Daniel Hastings MIT's Interim Vice Chancellor, challenged conventional thinking about systems engineering for the current era. *"We're in the third age of space, driven by a great many entrepreneurial efforts and reduced launch costs,"* he noted, pointing to massive, decentralized architectures like Starlink where functions are distributed across networks of flying computers rather than residing in individual satellites.

The session's emotional peak came when speakers shared personal journeys into systems engineering. Stefan Schlechtriem, DLR's Director of the Institute of Space Propulsion, emphasized the human dimension of interface management, recounting how his center succeeded by bringing diverse talent together, including multiple Australian engineers who found their way to Germany's rocket testing facilities.

The session concluded with a ceremonial signing of a "call for action" document emphasizing that systems engineering competencies require lifelong development, cannot be fully taught at universities' first level, and demand multidisciplinary platforms that transcend traditional academic silos.

Wednesday's GNF sessions painted a portrait of a space sector at a crucial inflection point. From Switzerland's orbital traffic warnings to India's explosive commercial growth, from workforce competency challenges to innovation opportunities, the discussions revealed an industry simultaneously confronting urgent sustainability crises and unprecedented commercial possibilities. The recurring theme was collaboration, whether between nations managing orbital congestion, between academia and industry developing systems engineers, or between established and emerging space nations building equitable partnerships.

As the sessions made clear, success in this new era requires more than technological innovation. It demands new frameworks for international cooperation, fresh approaches to workforce development, creative business models connecting space capabilities to terrestrial markets, and inclusive partnerships that recognize diverse national priorities.

Thursday
2 October 2025

Thursday showcased seven Global Networking Forum panels exploring humanity's expanding ambitions in space, from building lunar infrastructure and extracting resources to establishing space-based AI systems and responsive defense capabilities. The sessions highlighted a fundamental shift in how the space community approaches exploration, moving from theoretical concepts to practical implementation, with industry leaders demonstrating technologies already operating on the Moon and in orbit. Throughout the day, panelists emphasized that collaboration across borders, industries, and disciplines has become essential for realizing ambitious space ventures, while the discussions revealed both the extraordinary progress achieved and the complex challenges that remain.

The first morning session, **"Space Computing: Global Open Science and AI in Space"** introduced China's ambitious Three Body Computing Constellation, representing the first space-based intelligent computing infrastructure supporting AI applications in orbit. Lijun Huang, Deputy Director of Space Computing Systems at Zhejiang Lab, announced that the first 12 satellites launched in May 2025 achieved a historic milestone by deploying an 8 billion parameter AI model in space for the first time. The constellation's computing satellites feature integrated CPU, GPU, and FPGA systems providing up to 10 petaflops of processing power per satellite, interconnected by laser links enabling communication speeds from 10 to 200 gigabits per second. Huang detailed applications ranging from solar observation data processing to real-time monitoring of UN Sustainable Development Goals, demonstrating how AI enables instant results rather than the months previously required. The session also introduced the Olive Leaf initiative, presented by Xu Yan, Vice President of Landspace Hongqing Technology, which offers free satellite ride-sharing opportunities for payloads from around the world. *"Space shouldn't be just for the few,"* Xu stated, emphasizing the program's goal of democratizing access to space for developing nations, students, and researchers. Quintin Parker, Director of Laboratory for Space Research at the Hong Kong University discussed AI's crucial role in addressing space debris through what he termed "SHARD" systems: Satellites Hunting Autonomously, which could be Risky, Remediating Debris. Parker warned that without AI-enabled autonomous debris removal systems deployed within the next few years, the Kessler Syndrome could become reality, making certain orbits unusable.

The Session **"Space Resources, from Sustainable Space Exploration to Benefits for Earth"** conducted by Pat Remias, Vice President of Space Systems Development at Blue Origin detailed the company's comprehensive approach to lunar infrastructure development. She outlined Blue Origin's family of Mark 1 and Mark 2 landers, with the first Mark 1 scheduled for launch before the end of 2025 and a second unit carrying NASA's Viper rover in late 2027. The session focused extensively on Blue Origin's Blue Alchemist technology, which uses molten regolith electrolysis to extract oxygen, silicon, aluminum, and rare earth metals directly from lunar soil. The company's Oasis-1 mission, announced in partnership with Luxembourg, will launch in 2027-2028 to map water ice locations at the lunar South Pole using radar and hyperspectral imaging. The presentation emphasized the economic logic of

in-situ resource utilization, noting that manufacturing capabilities on the Moon, though requiring tens or hundreds of millions of dollars to deploy, have become far more economical than continuously launching materials from Earth when operating for 10–15-year lifespans. Remias also discussed potential terrestrial applications for extracted resources, particularly helium-3's value for quantum computing and medical applications, noting its potential value of tens of millions of dollars per kilogram on Earth.

The midday session **"Chang'E Lunar Sample Scientific Research"** was a reminder of the recognition of the Chang'E 6 mission's achievement returning samples from the far side of the Moon by the IAF's World Space Award 2025 (Team category).

Feng Guan, Director of Lunar Exploration and Space Engineering Center of at the China National Space Administration revealed groundbreaking discoveries that are reshaping our understanding of lunar evolution. The research confirmed volcanic activity as recently as 120 million years ago during Earth's Late Cretaceous period, challenging the long-held belief that the Moon became geologically dead over a billion years ago. The samples also provided the first evidence of lunar magnetic field strengthening at 2.8 billion years ago, contradicting previous models of continuous decline. Guan announced the opening of international applications for Chang'E 5 lunar samples, with seven research institutions from six countries already approved and receiving materials. *"It is hoped that scientists around the world will use lunar samples from China's Chang'E project to discover more materials,"* Director Guang stated, highlighting China's commitment to international scientific collaboration.

The session wittingly titled **"ROCK and ROLL: Striking a Chord Between Terrestrial Mining Advancements and Space Resource Utilization Opportunities"** brought together experts from mining, aerospace, and research institutions to explore synergies between Earth-based extraction technologies and lunar operations. Jun Shimada, Lead for ISRU Research at JAXA Space Exploration Center, moderated the discussion.

Marianne Cummings, Director of Strategic Development at AUSTMINE, presented findings from a comprehensive report examining technology overlaps between mining and space sectors. The research revealed a circular flow of innovation, with technologies initially developed for space missions being adopted in mining, then further refined and "spun back" into space applications. Cummings identified key challenges preventing greater collaboration, including lack of common knowledge and differing terminology that leads to miscommunication between sectors. Angel Abbud-Madrid, Director of Space Resources Program at the Colorado School of Mines emphasized the critical role of education in bridging these gaps, advocating for interdisciplinary courses combining space science and mining engineering. Mark Sonter, Chairman of Off Earth Resources, offered a sobering economic perspective, noting that while asteroid mining has been *"a dozen years away"* for several decades, the convergence of enabling technologies suggests commercial operations may finally emerge within five to ten years. *"I would like to be there,"* Sonter stated, revealing that his team is actively seeking seed funding for asteroid mining projects. The panel concluded with calls for improved legal frameworks, as Andrew Dempster, Director of the Australian Centre for Space Engineering Research (ACSER) at the University of New South Wales emphasized, *"No mining company is going to dig something up if they don't even know if they own it when they've done it."*

In an innovative format for the IAC, the session **"Sharing Space: how Satellite Constellations and Astronomy can Co-Exist"** took the form of a game "moderated by Sara Webb, Course Director and Program Lead from Swinburne University of Technology. The panel brought together industry representatives from Amazon's Project Kuiper and SpaceX with astronomers from the Australian National University and the Square Kilometre Array Observatory, along with the Australian Space Agency. Philip Diamond, Director General of the Square Kilometre

Array Observatory (SKAO), described the challenge posed by rapidly expanding satellite constellations, particularly the unexpected electromagnetic radiation from onboard electronics detected by low-frequency telescopes. *"It was totally unexpected. We didn't expect to see it and SpaceX didn't expect us to be able to detect it,"* Diamond noted, though praising SpaceX's responsive approach to addressing the issue. Josef Koller, Head of Space Safety and Sustainability at Amazon Project Kuiper, emphasized that collaboration between astronomers and satellite operators must begin early in the design process rather than after problems emerge. The session highlighted technical solutions being developed on both sides, from satellite manufacturers implementing mitigation measures to astronomers developing new observation techniques. Catherine Grace, Acting General Manager for Space Capability with the Australian Space Agency, emphasized the government's role in facilitating multi-stakeholder engagement, particularly ensuring voices from First Nations communities and developing nations are included in discussions about preserving dark and quiet skies.

Thierry Klein, President of Bell Labs Solutions Research at Nokia conducted a session *"Out of this World: Building a Mobile Network on the Moon"*, demonstrating how terrestrial telecommunications technology is being adapted for space exploration. He detailed the successful deployment of the first lunar network earlier in 2025, part of the Artemis II mission. The speaker emphasized that space exploration's new era requires different communication infrastructure than the Apollo missions, where limited UHF radios connected just two astronauts. With plans for semi-permanent lunar presence, resource mining, and extensive scientific operations, the need for high-bandwidth, low-latency networks becomes critical. The Nokia system achieved 10 kilometers of range on the lunar surface and demonstrated capabilities for hundreds of megabits per second data transmission, dramatically exceeding the bandwidth needed for grainy black and white footage of previous missions. Klein noted that the lunar network represents just the beginning, with plans to extend similar infrastructure to Mars, though acknowledging that the increased distance will necessitate even greater reliance on autonomous operations and edge computing. The presentation concluded with an invitation for collaboration across the space industry, recognizing that innovation thrives at the intersection of different sectors.

The final session of a day, **"Tactically Responsive Space"** was moderated by Sam Peterson, Founding Partner of Cislunar International and Adjunct Professor at Embry-Riddle Aeronautical University. Eric Salwan, Co-founder and Director of Commercial Business Development at Firefly Aerospace, described his company's historic Victus Nox mission, which demonstrated the ability to complete final orbital selection, payload encapsulation, integration, and launch within 24 hours. *"That was the first time that's ever been done,"* Salwan stated, noting that the capability provides both rapid replacement of compromised assets and

serves as a deterrent against adversaries. Jeff Thornburg, Co-founder and CEO of Portal Space Systems, presented his company's Supernova spacecraft, described as the world's first solar thermal powered high Delta V platform capable of traveling from medium Earth orbit to low Earth orbit in hours and from LEO to lunar orbit in under four days. Thornburg characterized the system as *"the iPhone of spacecraft platforms,"* designed to move away from bespoke spacecraft for every mission toward a versatile transorbital service. Luca Rossettini, Founder and CEO of D-Orbit, discussed the infrastructure needed for space logistics, detailing his company's completion of 21 space missions delivering over 200 payloads. The panel addressed procurement challenges, with Rossettini noting that even advanced nations struggle with integrating service-based models into traditional asset-based procurement processes. When asked for advice for space entrepreneurs, all three founders emphasized resilience and persistence. *"It's going to be a long journey, guys, a lot of sweat and blood,"* Rossettini cautioned, adding, *"But don't give up."*

The seven GNF sessions on Thursday revealed a space sector in rapid transformation, characterized by unprecedented international scientific collaboration, practical deployment of advanced technologies, and growing convergence between terrestrial and space industries. From China's opening of lunar samples to international researchers and the democratization of space access through initiatives like Olive Leaf, the day showcased a sector increasingly focused on inclusive participation. The sessions demonstrated that many technologies once considered theoretical are now operational, with networks functioning on the Moon, AI systems processing data in orbit, and companies preparing to extract and utilize lunar resources. Yet panelists repeatedly emphasized that technical capabilities alone cannot ensure success. Legal frameworks for resource ownership, procurement processes that accommodate service-based models, standardization enabling interoperability, and continued dialogue between stakeholders with competing interests emerged as critical challenges requiring immediate attention. As the space sector expands its presence beyond Earth, Thursday's discussions made clear that progress depends not just on engineering excellence but on the ability to build trust, facilitate collaboration across borders and industries, and ensure that space exploration benefits all of humanity.

Friday
3 October 2025

As the final day of the 2025 International Astronautical Congress unfolded, the Global Networking Forum sessions took on a reflective quality, with space leaders and pioneers gathering to celebrate milestones while challenging the community to think more inclusively about humanity's shared future beyond Earth. From inspiring public engagement to honoring a quarter century of continuous human presence in orbit to confronting difficult questions about who gets to shape our interplanetary destiny, Friday's sessions underscored a fundamental tension: space exploration has never been more technically achievable, yet the work of making it truly accessible and beneficial to all has only just begun.

The day started with awaited session **"25 Years of Continued Astronaut Presence on ISS: A True Human Outpost in Space"** which brought together six veteran astronauts whose combined experience totaled 1,039 days aboard the station. Moderated by Canadian Astronaut Julie Payette, currently President of the Association of Space Explorers, who flew on two ISS assembly missions, the panel featured an extraordinary assemblage of spacefaring experience: Korea's first and only astronaut So-yeon Yi, Japan's Koichi Wakata with his record five spaceflights, Denmark's Andreas Mogensen as the longest-serving European ISS commander, Türkiye's first astronaut Alper Gezeravcı from the recent Axiom-3 mission, and former NASA's Andrew Feustel, currently Lead Astronaut for Vast, with nine spacewalks under his belt.

The session opened with a powerful message from current ISS Commander Cosmonaut Sergey Ryzhikov, who, together with seven crew members - three Americans, three Russians, and one Japanese astronaut –continues humanity's unbroken presence in orbit. His words resonated through the room: *"In these challenging times, when humanity faces new and dangerous challenges, our continuous collaboration serves as a ray of hope that peace, kindness, reason and love will prevail."* This message framed the entire discussion, emphasizing how the station has maintained international cooperation despite terrestrial tensions.

Koichi Wakata, now Astronaut and Chief Technology Officer of the Asia-Pacific region at Axiom Space, articulated the session's defining insight when asked about lessons from 25 years of continuous operations. *"If you want to go quickly, you can do it alone. But if you want to go further, we should do it together,"* he stated, explaining how international collaboration created technical resilience through dissimilar redundancy. When one nation's spacecraft or systems encountered problems, partners compensated, ensuring the station's survival and success. This interdependence, he argued, must be the foundation for future lunar and Martian exploration.

The discussion revealed intimate details of orbital life that technical reports rarely capture. Astronauts shared

their surprise at how quickly time passes in space despite long-duration missions, with Mogensen, ESA's Astronaut, noting that 200-day missions felt compressed because of constant activity and purpose. The panel addressed practical considerations for future deep-space missions, including what single personal item they would bring on a Mars journey. Responses ranged from music collections to internet access to hot sauce, revealing how small comforts maintain psychological well-being during isolation. Gezeravcı emphasized better recording capabilities to capture and share the experience while emphasizing that he *"didn't go to space to miss something"* and that it's a great privilege to do so, while Yi advocated for internet connectivity to access procedures and knowledge independently.

When asked whether viewing Earth without borders changes perspective on world events, Payette offered a nuanced response that encapsulated the session's spirit. Rather than claiming orbital experience resolves terrestrial conflicts, she emphasized how spaceflight reinforces the importance of finding common ground, maintaining respect and integrity, and acknowledging that no single nation or individual possesses all answers. The station's survival for 25 years, she argued, demonstrates that international collaboration works and brings tangible benefits - a message the space community must champion as humanity ventures further into the cosmos.

What followed was a session **"Beyond Buzz: Public Engagement Strategies for a Space-Ready Society,"** where industry leaders converged to address the critical challenge of translating space achievements into public understanding and support. Moderated by Stan Crow, Board Chair of the World Space Week Association, the session brought together voices spanning satellite operations, science communication, and digital innovation to explore why space engagement matters and how to sustain it across generations.

Candace Johnson, Co-Initiator of SES and pioneer in satellite communications, set the tone by sharing her lifelong journey in space, from receiving a toy Sputnik ornament as a five-year-old in 1957 to her current work developing logistics and communication networks for lunar and Martian operations. Her emotional reflection captured the session's central theme: *"I had tears in my eyes seeing these young people just going and discovering all of the great things that space can do."* This observation highlighted a recurring challenge raised throughout the discussion: how to maintain the wonder that naturally captivates children while demonstrating space technology's practical applications to address Earth's challenges.

Sara Webb, Course Director and Program Lead at Swinburne University of Technology, emphasized the importance of early engagement, recounting how her childhood question about the universe's edge launched a lifelong quest for answers. Now leading her university's microgravity platform, which has sent multiple payloads to the International Space Station, Webb stressed the need for accessible educational experiences: *"All of them are dedicated to inspiring the next generation and giving them educational tools and experiences."* Her work exemplifies how hands-on opportunities can transform casual interest into sustained engagement with space science.

The discussion revealed a stark reality about engagement gaps. While young children show equal enthusiasm for space regardless of background, participants identified a significant drop-off during adolescence, particularly among disadvantaged communities. Atsushi Takata, Executive Vice President for Global Strategy and Space Utilization at Space Data, shared his company's work creating a digital twin of the International Space Station, reflecting on his vision to build a world where his five-year-old daughter could easily choose to go to space by the time she reaches adulthood. This long-term thinking contrasted with immediate challenges raised by audience members, including a University of Alabama Huntsville student who described systematic barriers facing student-led space projects in academic settings.

Natavan Hasanova, Strategy and Business Development Director at Azercosmos provided crucial perspective from an emerging space nation. Her emphasis on making space engagement dynamic and accessible highlighted how countries newer to space activities approach public outreach differently, often with fewer resources but equal enthusiasm. The session concluded with participants

agreeing that effective engagement requires moving beyond industry silos, demonstrating practical benefits of space technology, and creating multiple pathways for sustained involvement across all socioeconomic backgrounds.

The day concluded with **"Becoming Interplanetary: World Premiere Film Screening and Interactive Dialogue,"** a departure from typical technical presentations. Moderated by Elena Rocchi, Director of MSD Program, Space Architecture & Extreme Environment at Arizona State University with a support of Jessica Rousset, Executive Director of Strategic Initiatives, Office of the Vice President of Research, Knowledge Enterprise as Arizona State University, the session premiered a 32-minute film featuring 22 experts examining humanity's drive to explore and the lessons history offers as we become a multi-planetary species. The film deliberately raised questions rather than providing answers, designed to generate dialogue about doing space exploration more thoughtfully than past terrestrial exploration.

Following the screening, panelists engaged with an audience that included numerous families and children, drawn by the Congress's Public Day. Chris Hadfield, retired Astronaut and ISS Commander, whose opening remarks in the film challenged viewers to think about learning from human history to *"do this as right as we possibly can,"* could not attend in person but followed remotely. The live discussion featured Jim Bell, Professor in the School of Earth and Space Exploration at Arizona State; Dava Newman, Director of the MIT Media Lab; Tanja Masson-Zwaan, Assistant Professor and Deputy Director of the International Institute of Air and Space Law at Leiden University, and President Emerita of the International Institute of Space Law (IISL); and Guillermo Trotti, professor, Co-founder and Chairman at Arizona State University, EarthDNA and Trotti Studio, architect and designer focused on space habitation.

Newman provided a scientific perspective, emphasizing the search for life beyond Earth as a primary driver of exploration. While acknowledging Mars as the obvious near-term destination, she expressed surprising enthusiasm for Europa, where a liquid water ocean two- or three-times Earth's ocean volume sits in contact with a hot silicate crust. *"Who knows what's swimming in the oceans of Europa today?"* she asked, emphasizing that discovering whether we are alone requires human presence, not just robotic missions. Her career focuses on robotic avatars, she noted, stems from practical necessity, not preference - we send robots because we cannot yet go ourselves.

Masson-Zwaan addressed the legal frameworks needed for responsible space settlement, arguing that humanity's innate drive to explore should not be suppressed but rather channeled through coordinated regulation ensuring equitable benefit. *"The values of humanity have to be preserved,"* she stated, emphasizing that doing space exploration together represents the central challenge. She suggested that legal innovations, including smart contracts and AI-assisted negotiation tools, might facilitate the consensus-building required for effective international agreements.

Trotti, drawing on his experience sailing around the world and studying Polynesian exploration patterns, advocated for a cautious, incremental approach. Just as Pacific Islanders moved from visible island to visible island rather than venturing blindly into an unknown ocean, he argued the Moon serves as humanity's first island: close enough to return home if something goes wrong, perfect for developing life support systems, structures, and propulsion before attempting Mars or Europa. His nautical metaphor resonated with the film's exploration themes, connecting contemporary space ambitions to humanity's ancient seafaring traditions.

The panelists identified a shared concern that emerged strongly from audience responses: the risk of failing to learn from past terrestrial exploration. The film and discussion emphasized that becoming interplanetary requires not just technical capability, but wisdom drawn from centuries of human migration, colonization, and their often-devastating impacts on indigenous peoples and ecosystems. Newman captured the session's aspirational tone: *"Let's learn from the ancient wisdoms. We are new at this, so let's be respectful."* She noted how all cultures throughout history have looked to the stars and Moon, suggesting that our shared gaze upward should remind us of our common humanity on "Spaceship Earth."

The session concluded with an invitation for organizations worldwide to screen the film during World Space Week and beyond, using a provided facilitation guide to generate local dialogues. Rocchi, visibly moved, reflected on how design and imagination can serve as universal languages for discussing humanity's space future: *"We design because we desire to do things."* Her closing words - "Continuara" (it will continue)—captured both the project's ongoing nature and the broader message that humanity's journey to becoming interplanetary, while fraught with challenges and ethical complexities, represents an inevitable continuation of our species' exploratory drive.

Friday's three GNF sessions wove together past, present, and future, celebrating achievements while acknowledging gaps in accessibility, honoring international collaboration while recognizing its fragility, and embracing humanity's exploratory nature while insisting we learn from historical mistakes. The panels demonstrated that technical and commercial progress, while impressive, mean little without parallel advancement in how we engage diverse publics, maintain cooperative frameworks despite geopolitical tensions, and thoughtfully consider who benefits from and participates in shaping our off-world future. ■

IAC 2025

Special Sessions

SpS

Monday
29 September 2025

Earth Observation, AI, and Drone Technology for Wildfire Management

Wildfires/bushfires are an increasingly pervasive global challenge. Climate driven heat waves and longer, drier fire seasons, combined with expanding human development in fire prone landscapes, have amplified both the frequency and intensity of these events. The consequences are severe: lives are lost, public health is compromised by smoke, critical infrastructure is damaged, and biodiversity is threatened. Simultaneously, the economic burden of mitigation, suppression, and recovery is rising sharply. Traditional detection, monitoring, and mitigation approaches struggle to keep pace.

This interactive session engaged participants to be part of the wildfire/bushfire solution. Over 70 participants, most of whom possess a basic understanding of wildfire technology, engaged with session leaders Anna Moore and Marta Yebra from the Australian National University, Thomas Grübler of OroraTech, Paulo De Souza from Edith Cowan University and Lora Koenig of Lockheed Martin. Together they explored crowd selected questions concerning the use of remote sensing in fire management and the development of integrated fire resilience systems, brainstorming the obstacles that hinder progress and identifying next steps.

For remote sensing assets, challenges identified included insufficient edge computing capacity, a high rate of false alarms in fire detection caused primarily by persistent/transient heat sources. Participants note that smoke and clouds obscuring/interfering with remote sensing techniques affect detection performance and the acquisition of fire management related information (e.g. fuel condition) thus limited their use in land management practices. Proposed solutions included applying AI to filter false positives and improving access to standardized data sets for AI pipelines.

Regarding integrated fire resilience systems, challenges involved the complexity of physical processes crossing jurisdictional boundaries, disparate data formats that make data sharing complicated, a lack of common communications protocols across data networks and emergency/responder systems, and an overemphasis on response rather than prevention. Participants suggested solutions included expanding public outreach on prevention strategies and the value of early-warning technologies, creating testbeds that link ground and space-based technologies, and advancing automated, interoperable tools to link space, aerial, and ground data for unified fire monitoring and management.

Adopting and scaling wildfire/bushfire technologies is essential to enhance situational awareness, accelerate response times, reduce false alarms, and enable proactive, science-driven management of wildfire risk worldwide.

Figure 1: Two discussion questions were chosen by Special Session participants leading to an engaging interactive session on wildfire/bushfire technology.

Figure 2: Interactive word cloud shows the global audience and application for this Special Session.

Monday
29 September 2025

From Down Under to the Stars: Advancements and Opportunities in Human Health in Space

Space medicine is an emerging field in the space industry. From biomanufacturing in orbit to unexpected medical breakthroughs made possible by microgravity, the field is driven by interdisciplinary innovation, advancements in engineering and experimental investigations. Although space medicine has seen remarkable growth in recent years, its development in Australia and New Zealand is still in its infancy

Fay Ghani, a Kiwi medical researcher at Mayo Clinic and University of Auckland alum, organized this special session to dynamically engage participants to learn about cutting-edge research and educational and training opportunities in space life sciences down under. The session focused on connecting students, young professionals, representatives of academic institutes and industry partners with leaders in the regional and global space medicine community.

Fay invited world-renowned clinicians and scientists to the session who provided their unique insights and experiences in space medicine. Dr Abba Zubair, a regenerative medicine and transfusion therapy expert at Mayo Clinic and who currently serves as Vice Dean of the Mayo Clinic Alix School of Medicine, shared his professional and personal journey in pioneering regenerative medicine research in space. He led NASA-funded missions that sent stem cells to the International Space Station to study their therapeutic potential in microgravity, earning him the NASA Exceptional Scientific Achievement Medal.

Dr Lisa Brown, a New Zealand trained Hepatobiliary and General Surgeon working at the Royal Melbourne Hospital and Peter MacCallum Cancer Center in Australia, discussed her experiences as a surgeon, researcher and passionate mentor in aerospace medicine. Dr Brown was a Research Fellow in aerospace medicine at The University of Oxford, volunteered with UN's Space 4 Women Network and leads the New Zealand Space Health Research Network. During the session, she discussed the growing opportunities in New Zealand to conduct space medicine research.

Dr Siddharth Rajput, a board-certified vascular surgeon and aerospace mentor, discussed how his rigorous clinical training in intensive care and general surgery to care for Earthbound patients directly informs surgical practice in space. A recipient of the Sir Ross and Sir Keith Smith scholarship, he studied at the Southern Hemisphere Space

Studies Program. He shared upcoming opportunities and advice to participants interested in space surgery, and his involvement as a core member of the Space Surgery Association since its founding in 2010.

The session closed with lively interaction from participants to propose future research ideas in Australia and New Zealand, and potential ways space medicine advances humanity.

Tuesday
30 September 2025

Early Warnings for All – From Satellites to Action

Global leaders from space agencies, the United Nations, and the private sector convened for the Special Session **"Early Warnings for All – From Satellites to Action."** Their goal was to engage each other and the audience to identify how this United Nations fostered goal. The leaders emphasized the critical role of space-based technologies. They highlighted how satellite data, digital platforms, and international collaboration are transforming disaster management—from prediction and preparedness to response and recovery.

Speakers noted that only a fraction of the world currently benefits from effective early warning coverage, with fewer than 10% of countries operating fully functional, end-to-end systems. This gap leaves vast populations—particularly in Africa and the Pacific—without reliable alerts or response plans. To close this divide, participants called for stronger partnerships between space agencies, governments, and local communities, ensuring that high-tech data is converted into actionable, trusted information on the ground.

The **International Charter on Space and Major Disasters,** involving 17 space agencies, was celebrated as a model for rapid, coordinated response. Alongside it, initiatives like **Copernicus** and **JAXA's GSMap** are advancing global monitoring and forecasting capabilities. Emerging tools such as **digital twins, AI-driven modeling,** and **ESRI's real-time GIS platforms** demonstrate how accessible data can empower decision-makers and non-specialists alike to anticipate and mitigate impacts.

The dialogue repeatedly returned to the "**last mile**" challenge—the human link between sophisticated data systems and community action. Participants stressed that education, training, and trusted communication networks are as vital as the technology itself. Investment in these areas, they argued, ensures that warnings translate into life-saving measures.

Ultimately, the session underscored that achieving Early Warnings for All depends on inclusive, transparent, and collaborative systems that connect satellites in orbit with people at risk on Earth—transforming information into preparedness, and preparedness into resilience.

Tuesday
30 September 2025

Workshop on Earth Observation AI Foundation Models

The workshop brought together leading researchers from ESA, University of Adelaide and Singapore's Nanyang Technological University (NTU) to explore cutting-edge AI applications for satellite and remote sensing technologies. Key themes emerged around addressing fundamental challenges in space-based AI systems.

Data Scarcity and Synthetic Data Generation: **Researchers** demonstrated novel approaches to overcome limited training data for specialized modalities like SAR and hyperspectral imagery. The University of Adelaide team presented methods for creating compact geospatial foundation models through knowledge distillation, reducing model size from 300M to under 20M parameters while maintaining performance. NTU showcased AI-driven techniques for generating synthetic SAR images from optical imagery, enabling automatic annotation and expanding training datasets.

Foundation Models for Generalization: Researchers emphasized zero-shot learning capabilities that enable AI systems to recognize novel categories and adapt to environmental changes without additional training. Context-aware architectures demonstrated significant improvements in object detection and segmentation tasks, particularly for remote sensing applications where surrounding environmental information is critical for accurate classification.

Edge Computing and Hardware Reliability: The workshop highlighted successful deployment of geospatial AI models on space-qualified hardware, including flight-representative testing on systems like the Kanyini satellite. Key achievements include efficient FP16 inference with inference times under 6 seconds per tile, peak power consumption around 6-7W, and model sizes suitable for onboard storage constraints.

Future Directions: Participants identified multimodal AI integration combining satellite imagery with atmospheric and sensor data as essential for comprehensive natural disaster monitoring. The development of unified foundation models supporting flexible inference across multiple data types represents the next frontier in space-based AI capabilities.

Tuesday
30 September 2025

The Artemis Accords: Safe, Sustainable, and Transparent Space Exploration

On **September 30, 2025**, representatives from **Australia, Canada, India, the United States, and Peru** convened for a special session titled "The Artemis Accords: Safe, Sustainable, and Transparent Space Exploration." This international dialogue brought together key voices to share insights on how their nations are implementing the Accords to promote Sustainable Space – Resilient Earth.

The session was moderated by Stéphanie Durand, Vice President of Policy, Communications and Strategic Planning at the Canadian Space Agency, who skillfully guided the conversation to explore each country's priorities in deep space exploration and the role of the Artemis Accords in shaping responsible space practices.

Panelists included:

- Christopher De Luis, General Manager, Office of the Space Regulator, Australian Space Agency
- Major General Melgar Sheen, Head of the Peruvian Space Agency (CONIDA)
- Casey Swails, Deputy Associate Administrator, NASA
- Ganesh Pillai, Scientific Secretary, Indian Space Research Organisation (ISRO)

The discussion offered a rich exchange of perspectives—from emerging space programs to well-established agencies—on how transparency, safety, and sustainability are being prioritized in deep-space missions. Audience members engaged with probing questions, highlighting the importance of collaboration and shared responsibility in space governance.

This session underscored the **global commitment** of Artemis Accords signatories to openness, cooperation, and the peaceful use of outer space. It also reinforced the importance of international dialogue in shaping a resilient future for Earth through sustainable space exploration.

Wednesday
1 October 2025

The Ethics of Space in Our Connected World - How Artificial Intelligence, Big Data and Legal and Ethical Rules Impact on Space Operations and Activities?

This Special panel Session was designed to foster interaction and exchange between expert representatives from across the space sector and the audience on how (and whether) sustainability in space is achieved in practice (*"resilience on earth and sustainability in space"*). The experts were all representatives from the major stakeholders in space, from large constellation operators, developers of next-generation commercial space habitats, regulatory level (UNOOSA/ITU), to experts on AI, theoretical physics and astrobiology, and space lawyers. The panel took its inspiration through the work and dialogue developed by a cross-sector space ethics working group set up in 2024 by CNES, coordinated by *Philippe Clerc*, that was charged WITH examining the ethical issues of space activities, initially how space-based data is used and made available (with accompanying serious issues as to its integrity, *Smith*), through to increasing concerns over debris and congestion. In short, the dialogue sought to discuss how consensus be achieved on the current challenges by space activities, and how to balance the needs of science exploration and preservation of society's outer space legacy in the face of the ongoing technology drive (*Cesari*).

With a full meeting room of about eighty audience participants, panellists and participants exchanged ideas and thoughts about the boundary conditions for sustainable and successful space ops, from the concern over increased use of spectrum, the ongoing need for connectivity (closing the digital divide remains an incomplete task), as well the forms of AI deployed for outer space. Some panellists (*Marais; Beccera*) reminded the audience about how long it had taken in billions of years to ensure management of life and society on Planet earth as it is now. There were calls for hedging expectations against the risks involved (*Marais*). Finding the balance between interests in expanding outer space activities, whilst maintaining the sustainability of the outer space environment (*Ciccorossi, Koller*) pervaded the discussion. UNOOSA Director (*Holla-Maini*) reminded the audience that not all technological progress is necessarily beneficial to humankind, and this would apply equally to life off earth. Many intervenors were concerned and focussed on AI, and the panellists *Koller* and *McMillan* explained and talked through the impact of AI on space and the methods for its integration in operations; AI should not be confused and cannot be replaced by LLM; operations ins space can and must be driven the law and calculations of physics alone; common perceptions of what AI is about were often misguided.

The session could easily have continued for longer; the conclusions reached, from the need for legitimacy of action (*Becerra*), information sharing (collision avoidance, *Koller*), assuring access to space for all (*Kaul*), extending spacecraft life cycle information with the ITU over and above notifications to UN (*Ciccorossi*), were all identified as now in demand to ensure effective control. The need to retain the human element in the decision-making loop came top of the list, along with the common responsibility of states for space activities and the need to regularly check the impact of technological developments (*Kaul*). Audience and panellists alike enjoyed the session and expressed their interest in securing a follow-up discussion; as the volume and type of services and operations in space continue to increase, this subject will not go away, and cannot be left to one session alone. The organisers and panellists agreed to exchange on future approaches as a follow-up. Many audience members have provided their feedback, and the interest in continuing this discourse remains high.

Wednesday
1 October 2025

Building Capacity for Emerging Space Ecosystems in Asia-Pacific (APAC)

The Special Session on Building Capacity for *Emerging Space Ecosystems in Asia-Pacific (APAC)* brought together policymakers, industry leaders, and researchers to explore how the region can accelerate its space capabilities through collaboration, innovation, and sustainability. Led by Mariam Naseem and co-organizer Mahhad Nayyer, and featuring experts Dr. Bruce Chesley, Lynette Tan, and Leonard de Guzman, the session engaged participants through interactive discussions and real-time polling to identify key challenges and opportunities shaping the future of the APAC space ecosystem.

An opening Mentimeter exercise set the stage, revealing that participants viewed economic constraints and policy gaps as the most significant hurdles to regional space development. Conversely, education, collaboration, and workforce development were identified as the greatest opportunities for capacity building. Human capital emerged as the top regional priority, with participants emphasizing that industry-government partnerships and investment in Earth observation and climate services would deliver the highest impact. Many also echoed the sentiment that "we must solve problems on Earth before venturing into the cis-lunar domain."

Session discussions explored four interconnected dimensions of space capacity building:

- Finance and Investment – Directing venture capital and private equity toward long-term value creation in emerging space markets, supported by policy signals that encourage sustained rather than short-term investment.

- Governance and Regional Cooperation – Strengthening government leadership, streamlining bureaucracy, and enhancing regional coordination to align public missions with private innovation.

- Education and Workforce Development – Expanding hands-on learning opportunities, such as small satellite projects and early exposure to technology, to build robust talent pipelines that transform ideas into viable enterprises.

- Climate and Sustainability – Leveraging space-based technologies to advance climate resilience and environmental stewardship, from wildfire detection to disaster response, supporting SDG 9 (Industry, Innovation & Infrastructure) and SDG 13 (Climate Action).

The session concluded that building space capacity in the Asia-Pacific must be a holistic and collaborative endeavour, integrating finance, governance, technology, and climate action. The path forward for emerging space nations in the region lies in collaboration, investment in people, and alignment between innovation and environmental responsibility.

Thursday
2 October 2025

Building Bridges – Taking Optical Networks to Earth Orbit and Beyond

This dynamic and forward-looking session brought together leaders from the space and telecommunications sectors to explore how Free-Space Optical Communications (FSOC) and terrestrial fibre technologies can converge to enable a truly interplanetary internet. Designed as an interactive forum, the IAC Special Session began with expert insights, followed by breakout discussions that culminated in the sharing of the groups' findings, laying the groundwork for a future SCAN Committee-sponsored whitepaper.

Speakers initially explored the various areas which must be addressed to realise an integrated terrestrial orbital optical network, including the demands of contemporary service providers, the deployment of non-terrestrial networks, and the challenges of implementing Reconfigurable Optical Add-Drop Multiplexer (ROADM) infrastructure in-orbit. Where capabilities such as dynamic routing in space, multi-orbit integration, and software-defined optical payloads are key enablers of scalable, resilient, and low-latency satellite-terrestrial networks.

Audience members examined the implications of such industry demands and the resulting shift in satellite operator roles, from service providers to platform providers. The session also promoted discussion of the implementation challenges, market monetisation strategies, constellation architectures, and information security concerns in cross-national routing.

Audience engagement was at the focus of the session, with rich dialogue on architecture design, technology roadmaps, and the future of AI-driven network management. The session's collaborative format fostered cross-sector understanding and highlighted the considerations of transitioning from experimental deployments to commercial operations.

As orbital optical communications mature, sessions like this are vital to shaping the future. The success of this format, combining expert input, group collaboration, and actionable outcomes, sets a strong precedent for future forums. Continued exploration of integrated optical architectures will be key to unlocking the next era of space connectivity.

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Thursday
2 October 2025

Emerging Technologies for Autonomous On-Orbit Servicing

On-orbit servicing promises to transform the capabilities and longevity of future satellite missions. Unlocking the autonomy required for proximity operations will demand emerging technologies from AI, robotics, and computer vision. This session explored the current landscape of on-orbit servicing through research, industry, and policy lenses to align innovation with operational and regulatory realities.

Speakers from ESA/ESTEC, BAE Systems, DLR, and Astroscale outlined the state of servicing operations today, followed by campfire discussions examining key challenges and opportunities across in-orbit servicing, assembly, and manufacturing (ISAM).

There was strong alignment that standardisation, sustainability, and legal clarity are essential to enable ISAM. Common interfaces are needed for repair and modular upgrades, but regulatory and liability frameworks remain the main bottlenecks beyond technical barriers. ISAM was viewed as a driver of operational sustainability, enabling life extension, refuelling, and de-orbiting for future missions.

Differences emerged between lenses: researchers stressed in-orbit validation and agency-led standards; policy participants emphasised security and controlled access; industry voices called for global coordination and government-backed markets to accelerate adoption. Standardisation was viewed both as a necessity and a security risk, making it easier for malicious actors to interface with both operational and retired assets.

All agreed that modular platform design underpins long-term viability, with early government support key to progress. Together, the groups envisaged a sustainable, standardised, and economically viable on-orbit servicing ecosystem.

To realise the full potential of ISAM, the sector must not only adopt new technologies but also lead in defining the rules that will govern proximity operations. By integrating emerging technologies with legal and policy frameworks that foster innovation in proximity operations, the on-orbit servicing community is poised to turn today's technical promise into tomorrow's operational standard.

Thursday
2 October 2025

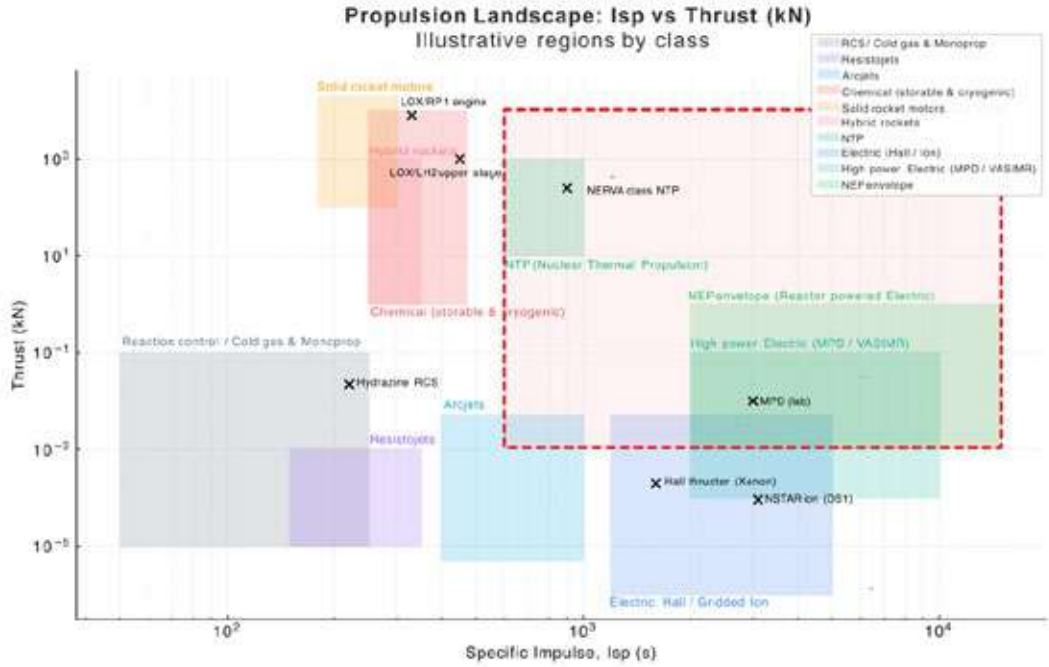
Empowering the Future: Space Nuclear Power and Propulsion for Sustainable Cislunar and Deep Space Exploration

As humanity ventures deeper into the solar system, the demand for reliable, high-power energy and efficient propulsion systems becomes increasingly critical. This special session convened leading experts from academia and government, to explore how Space Nuclear Power and Propulsion (SNPP) technologies can enable sustainable infrastructure for cislunar operations, long-duration missions to the Moon, Mars and exploration of the outer solar system.

The session opened with a strategic and historical overview by the moderator (Mr. Mitchell Schroll), highlighting nuclear's legacy in space and its emerging role in powering and propelling ambitious missions. Dr. Dale Thomas (University of Alabama in Huntsville) emphasized the importance of integrating power and propulsion systems, advocating for reliability and resilience as key attributes of successful nuclear technologies. He introduced the concept of making nuclear "boring" — where success is defined by predictability, self-correction, and safe failure modes, akin to an uneventful airplane ride. He also stressed the need for strategic sustainability through visible demonstrations, stakeholder engagement, and regulatory alignment. Dr. Mauro Augelli (UK Space Agency) highlighted nuclear's environmental necessity and superior power density, especially for lunar nights and Mars dust storms. He proposed a hybrid engineering approach and exploring the possibility of having Space Nuclear Institute to foster innovation and talent. Dr. Angelo Pasini (University of Pisa) discussed dual-use systems and novel ammonia-based nuclear propulsion, advocating for integration-friendly solutions and multidisciplinary training programs.

The panel addressed near-term demonstrators, scalability of fission systems, regulatory challenges, and the advantages of nuclear propulsion over chemical systems. Audience engagement emphasized international collaboration and commercial partnerships.

In conclusion, the session illuminated SNPP's pivotal role in future exploration architectures, with consensus around incremental demonstrations, integrated system design, and workforce development as essential steps toward a sustainable, nuclear-powered space future.



Friday
3 October 2025

Planetary Defense: A Space Crisis Simulation

A large asteroid is headed towards an impact in Western Africa 12 years from now if nothing is done. This is a realistic but entirely fictitious scenario from the 2023 Planetary Defense Conference (PDC) exercise, that is taking place every two years and brings together the world's planetary defense community.

After a general introduction of the topic by PDC Co-Chair Alex Karl, the ~30 participants were asked to form 5 groups and get to work! While there are many different topical fields to planetary defense, the participants were asked to zoom in on the media/communications aspects and pretend they were attending a workshop, and their assignment was to determine how to communicate the looming asteroid threat to the world. While most of us are not social scientists or professional communicators, we all are media consumers and have seen good and bad communications, so everyone had an opinion and something to contribute.

The first part of the workshop consisted of coming up with headlines that could be expected from the following sources: national news, international news, social media, and fake news.

The second part of the workshop put the participants in a different position and had them consider how they would respond if a close family member or friend would ask them about their opinion about headlines such as the ones they just generated in part 1.

The tables then took turns sharing their experience and outcomes of the two parts of the workshop. Not too surprisingly, the first part was fun. Participants enjoyed being creative and coming up with sensational headlines. Takeaways from the second part included that we, the space community, need to step up when needed and provide correct information to those around us even if we are not social media influencers as for our friends and family, we are a trusted source and can address the information vacuum before it is filled with nonsense.

Friday
3 October 2025

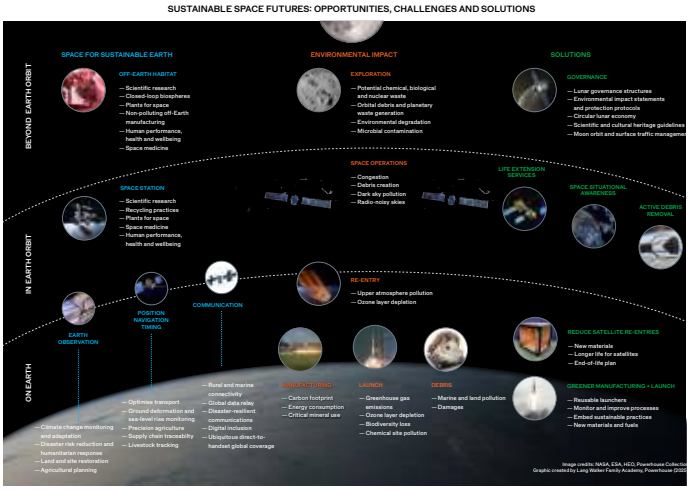
Empowering The Next Generation For A Sustainable Space Future

On 3 October 2025, Powerhouse convened an International Astronautical Congress (IAC) Special Session that assembled international space sustainability leaders, educators and industry experts to collaboratively design innovative learning challenges for high school students, utilising purpose-developed educational materials, organised and co-designed by Sophie Poisel (head of the Lang Walker Family Academy, Powerhouse) and Aude Vignelles (director of Vignelles Space).

The session commenced with a keynote address by Aarti Holla-Maini, director of the United Nations Office for Outer Space Affairs (UNOOSA), who presented critical real-world examples of space traffic coordination, including collision warnings involving multiple nations' satellites at proximities as close as 75 metres. Holla-Maini reported on UNOOSA's advancement in space object registration and outlined forthcoming regional capacity-building initiatives.

Vignelles introduced a comprehensive visual framework delineating sustainability challenges across three domains — on Earth, in orbit and beyond — while emphasising space-based benefits to terrestrial environments, thereby establishing the conceptual foundation for subsequent learning challenge development. This visual framework was designed for this session by Powerhouse with significant input from Poisel and Vignelles (see attached). We are currently gathering feedback on this image from the space community.

The co-design sprint, facilitated by Tim Parsons (chair of the Space Industry Association of Australia), generated eight curriculum-aligned learning programs spanning all three challenge domains. These included: sustainable lunar rover robotics with 3D modelling; cultural heritage protocols for lunar exploration; Earth observation engineering solutions for pollution mitigation; satellite life extension services integrating technical, business and policy perspectives; materials science investigations through density tower experiments; demonstrations of re-entry physics; lunar orbit traffic management; and Indigenous knowledge systems applied to space debris navigation. Participants collaborated directly with industry experts including Vignelles, Chris Blackerby (Astroscale), Julia Mitchell (Space Machines Company),



Imogen Rea (Space Industry Association of Australia), Mark Harrington (OroraTech) and Ceridwen Dovey (Powerhouse). The session utilised Powerhouse-designed materials comprising the Sustainable Space Futures subject review, curriculum cards, sustainability graphics and a program development framework.

Each prototype integrated multiple STEM curriculum outcomes — encompassing energy systems, data science, forces, First Nations knowledge systems, sustainability principles, materials science and engineering processes — while establishing authentic connections to industry challenges through field-based experiences and expert engagement. The session successfully established a direction towards an international space sustainability challenge for students and an international network, empowering educators to cultivate the next generation of responsible stewards of space environments. Interested participants may join the network at:
https://forms.office.com/r/i3viM4Byw

15th IAF International Meeting for Ministers and Members of Parliaments (MMoP 2025)

*In a gathering that underscored space technology's growing role as an indispensable tool for terrestrial concerns, 124 participants from 24 countries, including 53 designated representatives from Parliaments, Ministries and Governments from all over the world, convened in Sydney for the **15th IAF Meeting for Ministers and Members of Parliaments (MMoP)**. In addition to long-standing friends of the event such as France, Germany, and Romania, the meeting welcomed first-time participation from Bahrain, Uzbekistan, and New Zealand.*

The steady increase in participation over the years demonstrates the importance of creating a space event designed specifically for politicians, as well as the growing relevance of space technologies and data in governmental and parliamentary agendas.

For this gathering in Sydney, Dominique Tilmans, Special Advisor to the IAF President on Parliamentarian and Ministerial Relations, co-chaired the event with Steve Georganas, Federal Member for Adelaide and Co-Convenor of the Australian Federal Parliament's Parliamentary Friends of Space, who represented Tim Ayres, Federal Minister for Industry and Innovation and Minister for Science.

During his welcome remarks, Georganas framed the theme of the event, ***"Space: the Indispensable Ally for Decision-Makers,"*** with a pointed reflection on the core expectations citizens have of their governments. "When you think of members of Parliament or people that are making laws, the people that we represent expect a few things," he noted. "One is to know that they're secure when there's a

threat. Number two is to know that they will be provided for in terms of sustenance. Number three is to provide an economy that is workable." His message was clear: space plays a role in each of these fundamental responsibilities.

His colleagues Hon. Emily Suvaal, Parliamentary Secretary for Trade and Small Business of the New South Wales Government, and Hon. Judith Collins KC, New Zealand Minister for Space, further illustrated the region's commitment to using space technologies to address regional challenges, particularly disaster management. Since 1967, natural disasters have caused over $1 trillion in global damage, affecting more than 4 billion people. The Australian Space Agency's response includes developing new satellite capabilities and expanding ground-station infrastructure to support rapid emergency response across the vast Australian continent and its Pacific neighbors.

New Zealand's approach highlighted how mid-sized nations are carving out distinctive roles in the expanding space economy. Minister Judith Collins outlined ambitious plans despite operating the second-smallest space agency by budget in the OECD. Collins emphasized practical applications, from satellite monitoring of New Zealand's vast exclusive economic zone to supporting Pacific Island nations facing climate-driven risks. "We're quite a long way away from most other countries, but we're pretty close to Antarctica," she noted, situating New Zealand as a crucial launch corridor for polar missions.

The meeting's overarching theme echoed through three distinct sessions addressing ***Disaster and Risk Management, Support of Societies, and Solutions to Safeguard Life on Earth***. What emerged was not just technical capability, but a growing political will to harness space assets to tackle urgent terrestrial problems.

Introduced by a keynote presentation from Simonetta Cheli, Director of Earth Observation Programmes and Head of ESRIN at the European Space Agency (ESA), the first session focused on the support space-based solutions can provide to governments and public administrations across all stages of risk management, from prevention and preparedness to response and recovery.

Dr. Cheli's keynote was followed by presentations from a wide range of representatives: Madeleine Ogilvie, Minister for Innovation, Science and the Digital Economy of Tasmania; Sherzod Shermatov, Minister of Digital Technologies of Uzbekistan; Georgios Komodromos, Acting Permanent Secretary at the Cyprus Deputy Ministry of Research, Innovation and Digital Policy, Senator Hamilton Mourão of Brazil; Hon. Zeynep Yıldız, Member of the Grand National Assembly of Türkiye; and H.E. Ahmed Belhoul Al Falasi, UAE Minister of Sports and Chairman of the UAE Space Agency.

The second session addressed the broader role that space solutions play in tackling societal challenges and shaping policies that meet public needs. In recent years, space technologies have proven essential to policymakers in diverse sectors, from traffic management to optimizing energy and waste systems, from healthcare and emergency services to managing drinking water supplies.

This important topic was introduced by the day's second keynote speaker, Salem Al Qubaisi, Director General of the UAE Space Agency, and featured active participation from representatives of the Milli Mejlis (National Assembly of Azerbaijan) including Hon. Vugar Bayramov; Senator Claude Raynal of France; Stephen Dawson MLC, Minister for Regional Development, Ports, Science, Innovation, Medical Research, Kimberley and Pilbara (Western Australia); Trish White, former Minister for Science, Transport, Urban Development and Planning and astronaut; Brazilian Senator and astronaut Marcos Pontes; Jehad Abdulla AlFadhel, Second Deputy Chairman of Bahrain's Shura Council; Orsolya Ferencz, Hungarian Ministerial Commissioner for Space Research; Lene Westgaard-Halle of the Norwegian Storting; and Eugen-Remus Negoi, Member of the Romanian Senate's Committee on Communications, Information Technology, and Artificial Intelligence.

The final topic of the Meeting offered a clearer view of the breakthroughs space technologies provide in safeguarding life on Earth. These capabilities help combat illegal activities such as unregulated fishing, trafficking of goods, and illicit discharges from ships, while also enabling sustainable aquaculture planning, monitoring of water turbidity, and improved management of marine protected areas.

As highlighted by the Australian representatives, this topic is particularly relevant for Australia, a point reinforced by an outstanding keynote presentation from Enrico Palermo, Head of the Australian Space Agency. Its importance, however, extends far beyond Oceania, as demonstrated by contributions from Hon. Mario Kadastik of the Estonian Parliament and two representatives from Germany: Silke Launert, Parliamentary State Secretary of the Federal Ministry of Research, Technologies and Space, and Klaus-Peter Willsch, Chairperson of the Aerospace Group of the German Bundestag.

The MMoP Meeting concluded with remarks by Dominique Tilmans, who provided a brief overview of the programme for the upcoming days and, most importantly, invited all attendees to next year's event in Antalya, Türkiye, during the IAC 2026.

At the end of the day, participants experienced Aboriginal traditions and Australia's extraordinary natural environment during a private tour of the Royal Botanic Garden. In the evening, representatives and selected guests came together in a more informal setting to exchange insights from the day during the MMoP Dinner, held inside one of Australia's most cherished landmarks: the Sydney Opera House.

The IAF Global Space Leaders Summit

Bringing together the foremost leaders of the global space community, the IAF Global Leaders Summit stands as a premier platform for strategic dialogue among the heads of the world's space agencies and national space offices. This exclusive closed-door forum convenes annually the key decision-makers who are collectively shaping the future of space policy, exploration, and cooperation on a global scale.

The second edition of the IAF Global Space Leaders Summit, organized by the International Astronautical Federation (IAF) with the support of its esteemed IAF Member since 2011 and IAC 2025 Co-Host - the Australian Space Agency, took place on 30 September 2025 in Sydney, Australia, in conjunction with the 76th International Astronautical Congress (IAC 2025) under the visionary theme *"Global Space Governance: Shaping the Future Together"*.

As part of the Summit, the IAF traditionally presents to all participating heads of space agencies the IAF Space Leader's Pin - a uniquely crafted emblem featuring a moonstone and an individual serial number. The pin serves as a rare symbol of excellence in space leadership and a lasting tribute to each leader's contribution to the global space community. This year the IAF was proud to see eight newly appointed heads of space agencies and offices to the distinguished group of space leaders and to honour them with the IAF Space Leader's Pin.

Following the landmark 2024 Inaugural Session of the IAF Global Space Leaders Summit, where each of the participants delivered official statements to their global counterparts, the 2025 edition adopted a more interactive format.

40 Participating Heads of Worlds' Space Agencies and National Space Offices engaged during four moderated round tables focusing each on the timely topics of Space

Exploration, Earth Observation, Security, and Space Diplomacy, offering an unparalleled opportunity for shared vision, candid dialogue, and strategic alignment.

Josef Ashbacher, Director General of the European Space Agency (ESA), Lisa Campbell, President of the Canadian Space Agency (CSA), and Hiroshi Yamakawa, President of the Japan Aerospace Exploration Agency (JAXA), moderated the round table discussions on Security, Earth Observation and Space Diplomacy, respectively. The round table on Space Exploration was moderated by Amit Kshatriya, Associate Administrator of the National Aeronautics and Space Administration (NASA), who attended on behalf of NASA Acting Administrator Sean Duffy, who unfortunately had to cancel his participation last-minute.

"Relevance of space for security is increasingly recognized: There is no space without security, and there is no security without space", - Josef Aschbacher, Director General, European Space Agency (ESA).

"Today, space is placed an increasingly high priority by many countries in their policy agendas. The contribution through space programmes to society, economy, security and diplomacy is widely recognized" - Hiroshi Yamakawa, President, Japan Aerospace Exploration Agency (JAXA).

The third edition of the IAF Global Space Leaders Summit will take place on 6 October 2026 in Antalya, Türkiye, in conjunction with the 77th IAC.

The IAF International Astronauts Chapter

Among the many highlights of the landmark IAC 2025 was the IAF International Astronauts Chapter – a distinguished initiative launched in 2023 by the International Astronautical Federation (IAF).

The Chapter is a unique programme offers an exceptional opportunity to bring space heroes face-to-face with the IAF community and local public, offering firsthand insights as they share their experiences, expertise, and passion for space exploration.

The fourth edition of the IAF International Astronauts Chapter was jointly organized by the International Astronautical Federation (IAF) and the Australian Space Agency; and proudly funded by the IAF and the IAC 2025 Local Organising Committee (the Space Industry Association of Australia (SIAA), the NSW Government, and the Australian Space Agency).

Throughout the Congress week, more than 20 international astronauts from both government and the private sector took part in a wide range of outreach and educational activities - from engaging technical sessions on astronaut training, accommodation, and operations in space, the Global Networking Forum (GNF) panel, dedicated to 25 years of continued astronaut presence on the International Space Station (ISS), to press events and vibrant encounters with the public during the record-breaking Public Day and the following Sydney Science Festival.

One of the most cherished moments of the programme was the traditional autograph session, which once again proved to be a highlight for the public. To commemorate this rare gathering of global space explorers, IAC delegates and guests were invited to pick up a copy of the IAF Astronauts Chapter Booklet at the IAF Booth. This special collector's item, featuring photos of all participating astronauts, offered the perfect place to collect signatures - a meaningful keepsake of the meetings with these icons of human spaceflight.

Additionally, Australian astronauts Katherine Bennell-Pegg and Eric Philips proudly led their international colleagues in discovering the spirit of Australia through local experiences such as the Harbour Bridge Climb. The astronauts also met with First Nations communities to learn about Australia's deep cultural heritage and its profound connection to the stars.

"The International Astronauts Chapter of the IAF is trying to give people an opportunity to hear and share the astronaut perspective - people who had a chance to go above the Earth, contemplate our planet, fly in Space, participate in the great

endeavours of our time… People look at astronauts, and maybe it will sparkle an interest for the future, at least to study." - Julie Payette, Astronaut, President of the Association of the Space Explorers (ASE).

Through the IAF International Astronauts Chapter, the IAF continues to bring space closer to people, fostering inspiration, dialogue, and curiosity across generations.

IAC Hosts Summit - Twelfth Session

The Twelfth Session of the IAC Hosts Summit convened on Sunday 28 September at the International Convention & Exhibition Centre in Sydney, bringing together past, present, and prospective International Astronautical Congress (IAC) Hosts, along with senior representatives from the International Astronautical Federation (IAF), space agencies, and industry leaders. The summit provided a strategic platform to exchange insights into sponsorship, hosting challenges, inclusivity, and the evolving geopolitical context surrounding the world's premier global space event.

The session began with a short video highlighting the achievements and magnitude of previous IACs, followed by welcoming remarks from **Peter Martinez**, Chair of the IAF Congress and Symposium Advisory Committee (CSAC) and President of the Secure World Foundation (SWF). Martinez underscored the importance of continuity and collaboration across IAC hosts, emphasizing that each congress builds upon the legacy of inclusivity and international cooperation that defines the Federation's mission.

The keynote address, *"The Way to Mars Goes Through Switzerland – Fueled by Innovation IAC 2029,"* was delivered by **Raoul Keller**, Secretary General of SSIG at Swissmem – sponsor of this year's IAC Hosts Summit edition, and **David Cougoule**, Senior Manager at the Geneva Tourism & Conventions Foundation. The speakers highlighted Switzerland's commitment to technological excellence, sustainability, and innovation in preparation for bidding to host IAC 2029 in Geneva. They outlined how Swiss industry and academia aim to position the congress as a bridge between advanced manufacturing, research, and space exploration.

Moderated by **Steve Eisenhart** (Space Foundation, USA), the 40-minute panel **"Securing Sponsorship – The Backbone of a Successful IAC"** discussed strategies for attracting, maintaining, and maximizing sponsor engagement. Panelists included **Dunay Badirkhanov** (Azercosmos), **Christian Feichtinger** (IAF), **Lionel Suchet** (CNES), **Lisa Vitaris** (SIAA), and **Enrico Zappino** (AIDAA).

The discussion stressed that sponsorship is more than financial support – it is a collaborative partnership that enhances participant experience and long-term visibility for both the host and sponsors. Key takeaways included the importance of:

- Tailored sponsorship packages aligned with local industry strengths.
- Early engagement with potential sponsors through joint branding opportunities.
- Clear metrics demonstrating sponsor value and return on investment.

Panelists also cited the success of recent IACs in integrating sponsors into educational and networking opportunities, strengthening both community engagement and the overall congress experience.

The pitch session **"Ready to Take Off – Pitching Your IAC Vision for 2028** provided a platform for future bidders for IAC 2028 to present their proposals: **Manama (Bahrain), Mumbai (India)**, and **Samarkand (Uzbekistan)**. Each delegation delivered a 10-minute pitch outlining their logistical capabilities, scientific community engagement, and vision for fostering international participation.

The interactive Q&A segment, guided by the CSAC Chair, tested the bidders' readiness and long-term commitment.

- **Bahrain** emphasized resilience and adaptability, sharing how they overcame logistical challenges in preparing their bid.

- **Uzbekistan** demonstrated diplomatic tact by constructively assessing strengths and improvement areas among competing bids.

- **India** reaffirmed its strategic commitment to hosting future IACs, even if not selected for 2028, highlighting India's long-term vision for space diplomacy and education.

This segment effectively showcased the growing diversity of host candidates and reinforced the global reach of the IAF network.

The final 40-minute panel **"Hosting the IAC as a Bridge for Unity"**, moderated by Christian Feichtinger - IAF Executive Director, focused on the ethical and geopolitical dimensions of hosting the IAC. With contributions from **Maria Antonietta Perino (Thales Alenia Space), Jeremy Hallett (SIAA), Arif Karabeyoğlu (TUA), Clay Mowry (IAF/AIAA)**, and **Łukasz Wilczyński** (ESF), the discussion underscored the IAF's founding values such as neutrality, inclusiveness, and collaboration amid geopolitical complexity.

The following key issues were addressed:

- **Visa and accessibility challenges**, with several speakers noting that even IAF staff have faced visa difficulties for certain host nations. The panel strongly recommended that future bids address visa facilitation and inclusivity at the earliest stages.
- **Governmental support and continuity**, as highlighted by Hallett, emphasized that IAC's success depends on strong, stable partnerships between host governments and local organizers.
- **Cultural sensitivity and ethics**, revisiting past controversies to ensure transparent and inclusive host selection processes.
- **Geopolitical resilience**, with all panelists agreeing that the IAC must continue serving as an apolitical platform for global dialogue, true to its origins during the Cold War.

Christian Feichtinger concluded that, in line with a holistic approach, inclusivity - embracing administrative, geopolitical and cultural aspects, should be a formal evaluation criterion in future host selections to uphold the IAC's "bridge for unity" ethos.

In his closing reflections, Peter Martinez commended participants for their open and forward-looking dialogue. He reaffirmed the Federation's commitment to maintaining the IAC as a space for unity, collaboration, and shared progress. The session closed on an optimistic note, highlighting that while challenges remain, the global space community continues to demonstrate resilience and a collective spirit that transcends borders.

The Twelfth IAC Hosts Summit reaffirmed the Federation's dedication to inclusivity, cooperation, and innovation in future congresses. It strengthened the IAC's role as the bridge between nations, generations and gender, ensuring that future editions will continue to embody the spirit of global cooperation that defines the international space community.■

IAF Public Speaking and Presentation Skills Lab

The IAF Public Speaking and Presentation Skills Lab (IAF PS Lab) was held on 28 September as an associated event of the 76th International Astronautical Congress (IAC). The workshop addressed the growing need for effective communication within the international space community, particularly as new frameworks are being developed for space traffic management.

The session was co-moderated by Matias Campos, CEO and Founder of Astralintu Space Technologies and Vice-Chair of the IAF Administrative Committee on Connecting Emerging Space Ecosystems (IAF ACCESS), and Ioana Roxana Perrier, Professor Space Science and Physics at Institut Polytechnique des Sciences Avancées (IPSA) Air and Space Engineering School. The objective of the workshop was to strengthen participants' public speaking and presentation skills in a multicultural and international environment.

The workshop brought together participants from diverse backgrounds, including students, young professionals, and IAC presenters from around the world. It featured interactive activities such as best practices for IAC communication, elevator pitch exercises, and live feedback on lightning presentations. Key topics included techniques for effective public speaking, the role of body language, methods to manage stage fright, and approaches to engaging an international audience while navigating cultural differences.

The IAF PS Lab provided participants with practical tools and actionable feedback to enhance their confidence and presentation capabilities. The session was widely beneficial for speakers, students, and IAC participants seeking to improve their communication effectiveness in professional and international settings.

32nd Edition of the IAF Workshop with the Support of the UN

For more than thirty years, the International Astronautical Federation (IAF) and the United Nations have co-organized a technical workshop on Space Technology for Socio-Economic Benefits ahead of each IAC embracing the theme.

The 32nd edition of the IAF Workshop with the support of the United Nations was held in Sydney, Australia, from 26 to 28 September 2025, immediately prior to the seventy-sixth International Astronautical Congress (IAC 2025), and adopted a new dual focus - Space for Oceans and disaster-risk management - reflecting the IAC 2025 theme: "Sustainable Space : Resilient Earth."

The International Astronautical Federation (IAF) and the United Nations Office for Outer Space Affairs (UNOOSA) through the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) programme and the Maldives Space Research Organisation (MSRO), had jointly selected the theme *"Resilient Coasts, Resilient Earth: Innovative Space Solutions for Coastal Resilience and Emergency Management"*.

Coastal resilience is a pressing issue for the global community: the UN Regional Information Centre notes that around 40 % of the world's population lives near coastal areas and that the oceans support the livelihoods of more than 3 billion people. National Geographic's encyclopaedic entry on the ocean emphasises that Earth's ocean covers about 71 % of the planet's surface. Small island developing states control large exclusive economic zones; the UN Office of the High Representative for SIDS reports that SIDS control about 30 % of all oceans and seas. These facts underline the importance of integrating space technologies with coastal and ocean management.

The three-day event convened government officials, space-agency and marine-science experts, civil-protection authorities, academia, NGOs and industry to accelerate capacity-building in developing and frontline nations on the use of satellite applications for both ocean stewardship and disaster-risk reduction; and to forge partnerships, particularly for Small Island Developing States (SIDS).

The Workshop was oversubscribed – a total of 302 applications were received from 79 countries - including Maldives, Laos, Mexico, Kenya, Jamaica, Nicaragua, South Africa, El Salvador, Egypt, Seychelles, India, Indonesia, Spain, France, Australia, Samoa, Norway, Türkiye, China, Japan, the United States, Colombia, Cameroon, and many others - highlighting strong global interest. With the gender distribution of applications Male 59% vs Female 41%, most participants aged between 26 and 45.

Through valued efforts of the Workshop organizers 20 speakers were fully funded to attend and present at the Workshop in persons. In total, the workshop convened 92 participants from 50 countries, including 44 coastal countries and 6 Pacific nations. Participants ranged from senior executives of space agencies and private companies to local disaster managers, academics and young professionals, among them - 15 of the IAF global Emerging Space Leaders (ESL) awardees.

IAF Workshop with support of UN

The Workshop included various sessions, including presentations, fireside chats and dynamic round table discussions. A networking activity was organized at the end of each day, in which speakers and attendees could meet those working on the same topic to discuss their respective needs and the activities that they could undertake jointly.

In the welcome remarks IAF President Clay Mowry welcomed participants and celebrated the workshop's 32-year history, and UNOOSA Director Aarti Holla-Maini underlined the importance of inclusivity, innovation and integration via a recorded message.

IAF Executive Director Christian Feichtinger highlighted that this workshop has exemplified a unique partnership between the IAF and the United Nations, offering a platform where space technology is discussed not in isolation, but in service of humanity and socio-economic development.

Additional remarks from IAF CLIODN Chair Pieter van Beekhuizen and IAF ACCESS Vice Chair Matías Campos Abad highlighted the need to design with consequences in mind and the role of emerging space nations. Hamid Mehmood (UNOOSA) and Madin Maseeh (MSRO) framed the workshop at the intersection of space for oceans and disaster management: oceans cover 71 % of Earth's surface, that coasts host roughly 40 % of the world's population and that SIDS face increasing threats from sea-level rise, storms and flooding. Mehmood also emphasised that

The workshop demonstrated that satellite data, digital twins, geospatial AI and community engagement can bridge global technology and local decision making. Strengthening these links is essential for achieving UN Sustainable Development Goals 13 (climate action) and 14 (life below water).

UNOOSA Director Aarti Holla Maini summarised key messages, emphasising the need to convert prototypes into sustained services and recognising that resilient coasts depend on cooperation and the inherent resilience of coastal communities. IAF Vice-President for Relations with International Organizations Anil Kumar underlined the essential role of international partnerships in addressing shared space-related challenges. Representing the Host of the 77th International Astronautical Congress (IAC 2026), Ayhan Incirci, Director of International Relations at the Turkish Space Agency (TUA), warmly invited participants to join the 33rd edition of the UN/IAF Workshop in Antalya, Türkiye, to be held in conjunction with the IAC 2026.

IAF Envoy Initiative Workshop at IAC 2025: Advancing Inclusive Global Engagement in the Space Sector

The International Astronautical Federation (IAF) convened its first in-person IAF Envoy Initiative Workshop during the IAC 2025 in Sydney, marking a significant step in the Federation's efforts to widen global participation in the space domain. The Envoy Initiative, steered by the IAF Vice President for Membership Development and Financial Matters, Michal Brichta, was established in 2025 to expand awareness, inclusion, and collaboration across countries with limited or no formal representation in the global space community.

This inaugural workshop brought together an exceptionally diverse group of participants from across Latin America, Europe, Africa, Asia-Pacific, and Oceania, including representatives from Bolivia, Colombia, Bhutan, Slovakia, Pakistan, Uganda, New Zealand, and many others. Attendees ranged from government officials and academics to industry entrepreneurs, legal experts, and civil society advocates, all sharing a commitment to strengthening their national and regional space ecosystems.

The session opened with a clear articulation of purpose: to connect local ecosystem builders, exchange best practices, and foster global collaboration through a more inclusive and responsive engagement model. At the heart of the Envoy Initiative is a two-tiered approach that combines grassroots engagement with targeted high-level outreach. Envoys serve as liaisons between the IAF and emerging national space communities, while local "engagement drivers" champion development from within by mobilizing universities, startups, NGOs, and government bodies.

Early outcomes presented during the workshop highlighted how this approach has already enabled exploratory dialogues in several countries, helping identify stakeholders, map existing activities, and uncover needs ranging from capacity building and policy support to international mentoring. The IAF Bureau's recent approval of increasing the number of annually awarded grants for Emerging Space Leaders from 30 to 40, further demonstrates the Federation's commitment to ensuring the growth of opportunities matches the expansion of its global network.

A major focus of the workshop was the challenge of building sustainable space ecosystems in environments where institutional support, funding, and policy frameworks may be limited or uneven. Participants shared insights from their respective national and regional contexts, illustrating the wide variation in maturity and structure across emerging space nations. Examples highlighted how some countries struggle to coordinate efforts without a centralized space agency, contrasted with others that have developed nonprofit campus-style models to connect academia, industry, and government. Several participants emphasized the importance of linking engineering competencies with practical applications, such as agriculture, disaster response, and urban management, to demonstrate the tangible societal value of space technologies. Others described multi-year journeys of grassroots ecosystem formation, including community meetups and national directories of space companies, which ultimately helped governments recognize the value of appointing dedicated space leadership. Perspectives also included accounts of innovative private actors thriving even in the absence of national space agencies, as well as cases where cross-ministerial teams successfully coordinate national space activity and sustain pipelines of talent development and incubation programmes.

Contributions from African, Middle Eastern, and Asian participants added further depth, noting that many countries in these regions already have active universities and early government interest in space but lack meaningful international collaboration. One group underscored the need to support young professionals living and working within the continent, including through funding opportunities that enable participation in international events. Others noted how security concerns or institutional constraints can limit international cooperation and proposed a mix of top-down and bottom-up engagement and complementary access to IAF activities, along with more flexible access to

global activities, to help open doors. Several participants also shared insights from national initiatives designed to support startups through incubation, acceleration, and competitions, while underscoring the need for continuity beyond early-stage innovation activities.

Across all regions, common themes emerged: the persistent challenge of brain drain; the complexity of building an ecosystem that simultaneously cultivates talent, fosters industry growth, and facilitates international partnerships; and the uneven representation of nations at major global events such as the IAC. Participants emphasized that countries lacking formal space agencies or dedicated ministries are not necessarily at a disadvantage; what matters most is connecting local champions with international networks and tailoring support to each context. Capacity building, regional cooperation, and the strategic use of digital tools, including virtual collaboration platforms and multilingual AI-assisted translation, were identified as essential enablers that can help bridge geographical and linguistic divides.

The workshop concluded with a renewed commitment to strengthening country-level engagement, expanding online and hybrid activities, and empowering local actors who can advocate for space within their national ecosystems. Participants agreed that ecosystem development must be sustained, context-driven, and multidimensional, generating visible economic and societal benefits that resonate with policymakers and communities alike. As the Envoy Initiative continues to evolve, it promises to play a transformative role in linking emerging space nations, amplifying collaboration, and ensuring that the future of space exploration and innovation is truly global, inclusive, and interconnected.

IAF Space: The Big Picture Initiative (IAF SBP)

Since its creation in 1951, the International Astronautical Federation (IAF) has made every effort to turn its motto, "connecting all space people," *into a reality.*

Over the years, the space community has broadened, and as space technologies have become an inseparable part of national economies—serving as effective tools to tackle environmental challenges and protect our societies—the range of stakeholders shaping the global space ecosystem and benefiting from its achievements has significantly expanded.

To reflect these changes, in 2025 the IAF launched the **Space: The Big Picture (SBP)** initiative. This platform aims to directly engage stakeholders who, despite not being part of the traditional space community, are increasingly connected to it.

At the beginning of the year, the IAF Vice President for Global Membership Development, Michal Brichta, together with the IAF Secretariat, worked to identify leading global organizations that either benefit from space technologies or provide essential tools for the development of the space sector. These organizations included large technology companies, financial institutions, organizations focused on sustainability and security, and major users of satellite data solutions. They ranged from pharmaceutical companies testing products aboard the ISS to institutions financing innovative space companies; from international organizations that rely on space data for their programmes to IT companies enabling critical space technologies.

Representatives of these organizations were invited to join the **Space: The Big Picture Engagement Group**, which convened multiple times throughout the year to:

- Identify the goals and objectives of the IAF SBP Initiative
- Define membership of the IAF SBP Engagement Group and the process to further expand participation
- Draft the IAF SBP Terms of Reference

To ensure that the initiative accurately reflected the interests of the invited organizations, a survey was distributed among members of the Engagement Group to gather feedback on the programme.

IAF Space: The Big Picture

Members of the Engagement Group and other representatives from the IAF Community met in person during the IAF Spring Meetings in Paris, where the next steps of the initiative were presented.

This occasion also marked the beginning of preparations for the **IAF SBP Summit**, to be held within the framework of the International Astronautical Congress (IAC 2025) in Sydney, Australia. The summit aims to advance the initiative by bringing together the leadership of non-traditional space organizations and members of the IAF Community.

To ensure a productive meeting, a set of key discussion points—covering all items identified during the Engagement Group's work—was prepared and shared with confirmed participants and keynote speakers, along with a related survey. The results of this survey were presented during the event.

The final programme of the summit featured leading space organizations such as the European Space Agency (ESA), Axiom, Thales Alenia Space, UNOOSA, OSTIn, and BryceTech, who were invited to engage in dialogue with representatives of entities working in sectors not traditionally linked to space but nevertheless closely connected to it.

The first IAF SBP Summit focused on two central questions:

- *Why does the space economy matter, and who shapes it?*
- *How can we benefit from space technology?*

The inaugural IAF SBP Summit proved to be a great success and was marked by lively discussions among participants, which continued informally over a cocktail reception that provided additional opportunities for exchange in a relaxed setting.

The results of the Summit highlighted the importance of the SBP platform and the activities it plans to conduct in 2026, namely, cross-sectoral networking, knowledge sharing, and collaboration creation, as well as awareness building and outreach outside the space sector. The initiative also plans to significantly broaden the spectrum of engaged organisations and turn part of its activities public to build up an important link between the space community and the ever-growing number of stakeholders across relevant sectors.

IAC 2025
Closing Ceremony

As Sydney's harbor glittered beyond the windows of the International Convention Centre, the 76th International Astronautical Congress drew to a close on Friday with a ceremony that celebrated outstanding participation and marked a changing of the guard in the International Astronautical Federation's leadership. The gathering showcased a space community more vibrant and diverse than ever, with remarkable statistics underscoring the sector's explosive growth and global reach.

Christian Feichtinger, Executive Director of the International Astronautical Federation (IAF), opened the ceremony with a reflection on the week's extraordinary energy. *"What I will remember most personally is the incredible energy in the corridors, throughout the entire Congress center, in all the meeting rooms, in the plenary halls,"* he said. *"Despite the jet lag that many of you have experienced, this year we couldn't have chosen a more perfect location."*

The numbers told a compelling story of the space sector's expansion. 8,000 participants from nearly 100 countries attended the Congress, with more than half of all delegates under 35 years old. The event featured 193 exhibitors from 39 countries, 53 sponsors, and a staggering 3,450 papers presented across 200 Technical Sessions and five Interactive Presentation Sessions. The statistics represented not just growth but a fundamental shift in who participates in space activities.

The ceremony marked a pivotal leadership transition as Gabriella Arrigo formally assumed the presidency of the IAF from Clay Mowry. In her inaugural address as president, Arrigo paid tribute to her predecessor while outlining her vision for the federation. *"Clay leaves a strong legacy and I received a Federation in excellent health in its activities, its membership and its financial stability,"* she stated. Her motto for her tenure, **"back to the origins to discover the future,"** signals an approach that honors the Federation's founding principles while embracing innovation.

> "This week we gathered thousands of people from all over the world. We shared knowledge, technology, dreams and ideas. Once again we proved that space is not about one country, but about all humanity."

Arrigo announced several significant developments from the week's General Assembly sessions. The federation welcomed four new Vice Presidents and nearly 60 new members, bringing total membership to 604 organizations from 82 countries. In a particularly notable decision, members selected Samarkand, Uzbekistan as the host city for the IAC 2028, marking the event's continued expansion into emerging space nations.

Jeremy Hallett, Chair of the Local Organizing Committee and Executive Chair of the Space Industry Association of Australia, delivered a comprehensive tribute to the army of volunteers and professionals who made the Sydney congress possible. *"Based on the feedback I've received from a lot of you, I think we can safely say this has been an IAC for the ages,"* Hallett said.

The Closing Ceremony was also the moment of acknowledging the Awards bestowed on winners during the week: the IAF World Space Award (Jeff Bezos in Individual Category, Chang'E-6 mission for a Team); IAF Excellence in International Cooperation Award (Pascale Ehrenfreund), IAF Excellence in Industry Award (for OHB and D-ORBIT) and IAF Excellence in 3G+ (the Hong Kong Polytechnic University and Women in Aerospace Europe) and 2025 Interactive Presentation Awards. Besides reminders, the Closing Ceremony was also a moment of recognizing the winners of 2025 Frank J. Malina Astronautics Medal (awarded to Bernard H. Foing, CEO at ILEWG LUNEX EuroMoonMars, President at Space Renaissance International and Chief Scientist at QOSMOSYS). IAF Hall of Fame Awards were bestowed to Jeffrey Manber (Special Representative to the Chairman and CEO Voyager Technologies) and Tetsuo Yasaka (founding Member of the Space Debris Study

Group). Additionally, the 2025 IAF Young Pioneer Award was won by Riccardo Apa. Winners of Young Space Leaders Recognition Programme, IAF Emerging Space Leaders Programne and IAF Student Competition Award were also acknowledged and invited to the scene.

The ceremony devoted substantial time to recognizing the contributions of individuals and organizations that brought the congress to life. Lisa Vitaris, whose name prompted spontaneous applause even before Hallett could finish introducing her, served as the driving force behind the local organization. *"Everyone everywhere knows you and loves you, Lisa, which is a true testament to the way you have gone about putting on this event,"* Hallett said. His acknowledgments extended to the Space Industry Association of Australia team, the Australian Space Agency under Enrico Palermo's leadership, the New South Wales Government, and professional conference organizer MCI.

Looking ahead, the spotlight turned to Türkiye as Yusuf Kiraç, Chairman of the Board and President of the Turkish Space Agency, accepted the congress flag for the 2026 event in Antalya. *"It is a great honor for the Turkish Space Agency to receive the IAC flag today,"* Kiraç stated. *"We accept this responsibility with pride and commitment."* A promotional video showcased Antalya's stunning Mediterranean setting, positioning the 2026 Congress at what organizers called *"the crossroads of civilizations, where the blue of the sea meets the infinity of the sky."*

Feichtinger also drew attention to upcoming IAF events, including the Spring Meetings in Paris in March 2026 and the second Global Space Conference on Climate Change in Kigali, Rwanda in June 2026. The Rwanda conference, hosted by the Rwanda Space Agency, will focus on how space technologies can build climate resilience and represents the federation's growing engagement with African space initiatives.

Throughout the ceremony, speakers emphasized the collaborative spirit that defines the space sector. Arrigo captured this sentiment in her closing remarks: *"This*

week we gathered thousands of people from all over the world. We shared knowledge, technology, dreams and ideas. Once again we proved that space is not about one country, but about all humanity."

The ceremony concluded with Arrigo's promise to serve the federation *"with all my strength, my passion and my dedication,"* words that resonated with an audience already anticipating the 2026 gathering in Antalya.

The 76th International Astronautical Congress demonstrated that the space sector continues its remarkable evolution, attracting unprecedented numbers of young professionals and expanding into new geographic territories. Sydney's Harbour setting provided a fitting backdrop for a congress that looked both backward to the sector's achievements and forward to an increasingly collaborative and inclusive future among the stars.


2025 IAF EMERGING SPACE
LEADERS GRANT PROGRAMME


2025
IAF YOUNG


IAC 2025
TEAM

International Space Forum at Ministerial level

ISF 2025
INTERNATIONAL SPACE FORUM AT MINISTERIAL LEVEL
THE SOUTHEAST ASIAN CHAPTER

Manila, The Philippines | 4 December 2025

7th International Space Forum at Ministerial level (ISF) – The Southeast Asian Chapter

Fostering Regional Synergy in Space for Shared Challenges and Sustainable Development

Southeast Asia's rapidly growing need for space-based data took center stage at the ***IAF International Space Forum 2025 at Ministerial Level – Southeast Asian Chapter****, held on 4 December 2025 in Manila, Philippines under the theme* "Fostering Regional Synergy in Space for Shared Challenges and Sustainable Development"*. The seventh edition of the Forum, co-organized by the International Astronautical Federation (IAF) and the Italian Space Agency (ASI), and hosted this year by the Philippine Space Agency (PhilSA), brought together ministers, space leaders, scientists, and policymakers to chart a collaborative regional path for space-enabled development.*

Serving as Master of Ceremony, Christian Feichtinger, IAF Executive Director, guided the Forum's proceedings, ensuring an energizing flow of dialogue among Southeast Asian and international stakeholders. In addition to the high-level keynote speakers and ministerial statements, the Forum featured a joint press conference with the leadership of IAF, ASI, and PhilSA, who underscored the rising urgency for cooperation in accessing and applying satellite data for climate resilience and disaster preparedness.

Participation in ISF 2025 was notably strong, with representatives from five ASEAN countries, guest delegations from Tunisia and Türkiye, and seven international space agencies and organizations, as well as more than 35 observers from the region. Their contributions brought diverse technical, scientific, and policy perspectives to the discussions, demonstrating a shared recognition of space as a strategic enabler for sustainable development.

Gabriella Arrigo, emphasized during her inaugural intervention as new IAF President that her three-year presidential agenda aligns strongly with the goals of the International Space Forum. A core pillar of her agenda focuses on fostering an inclusive and open dialogue among IAF members and partners worldwide. She highlighted that such dialogue must involve not only space agencies and industry but also non-space sectors and broader civil society, reflecting the conviction that space is not merely an aspiration but a daily connection to technology, innovation, and the future. Welcoming the region's ambition, passion, and difficult questions, she noted that

these are essential to the IAF's mission of advancing global space governance. She reminded participants that the Federation offers unparalleled access to global space leaders and key decision-makers who shape the direction of the space sector.

Christian Feichtinger, speaking as both IAF Executive Director and ISF 2025 Master of Ceremony, emphasized the organization's commitment to inclusivity and to strengthening the participation of emerging space nations. He remarked that Asia is now among the fastest-growing regions within the IAF, with membership from this region rising more rapidly than anywhere else in the world. However, he cautioned that the true challenge lies not in the availability of satellite data, but in ensuring that countries have the knowledge, access, and training to use it effectively. Free and open data, combined with strong capacity-building programmes are essential to ensure that space-derived insights translate into real-world impact.

Gay Jane Perez, Officer-in-Charge of PhilSA, highlighted that Southeast Asia is one of the regions most exposed to climate extremes, with recent floods and disasters demonstrating the devastating consequences of delayed or insufficient data. She noted that the humanitarian and economic toll of recent disasters - lives lost, communities displaced, and infrastructure severely damaged, serves as a grim reminder that vulnerability transcends national borders. According to PhilSA's Officer in Charge, satellite-derived information is becoming indispensable for early warning, environmental monitoring, and responsive disaster management. She stressed that the IAF International Space Forum provides an important platform for policymakers, researchers, and stakeholders to envision a regional space ecosystem capable of informing development planning and safeguarding communities.

Echoing these points, Maria Chiara Noto, Vice-Director for International Affairs at ASI, remarked that while Asia offers immense opportunities for space innovation, it also faces significant challenges, including complex regulatory landscapes and frequent natural disasters. She emphasized that space cooperation is essential, and highlighted Italy's growing engagement with Asian partners through collaborations with Vietnam, Malaysia, and the ASEAN-Italy Cooperation Initiative on Space and Smart Technologies, which has strengthened regional partnerships since 2024.

The Forum's discussions revolved around three central themes: **developing regional space infrastructures, enhancing the use of space-enabled services, and strengthening the broader space value chain through policy, education, research, and collaboration**. Delegates collectively underscored that space technology is no longer a distant or specialized field, but a critical resource for addressing some of the region's most urgent concerns - from climate change and food security to maritime safety and social resilience.
PhilSA announced that it is working with ASI on a new memorandum of understanding that will formalize deeper cooperation in space infrastructure, applications, capacity building, policy development, and research. Additionally, with the Philippines set to chair ASEAN in 2026, the country plans to propose an ASEAN Declaration on Space Cooperation. The initiative aims to strengthen regional unity, promote confidence-building measures, and enable more structured coordination on space activities across Southeast Asia.

The Final Report of the Forum, including the **Manila Page Declaration**, compiles the insights, statements, and commitments expressed during the event. More than a summary of proceedings, the document stands as a testament to the region's determination to build a robust, resilient, and cooperative space ecosystem that serves its people and safeguards its future.

As the IAF Forum concluded, organizers expressed hope that the momentum generated in Manila will continue to inspire new collaborations within Southeast Asia and across the global space community. With climate challenges intensifying and economic modernization accelerating, the region's investment in space capabilities is poised to become a cornerstone of its long-term resilience and growth.

IAF Envoy Initiative Capacity Building Workshop for African Stakeholders

On 10 December 2025, the International Astronautical Federation (IAF), through its Envoy Initiative and the IAF ACCESS Africa Subcommittee, convened a regional capacity-building workshop designed to reinforce the rapid growth of Africa's emerging space nations.

The online workshop formed part of the IAF's broader objective to deepen strategic engagement across the continent ahead of major initiatives such as future IACs, IAF MMoP meetings, IAF Global Conferences, and dedicated capacity-building programmes. Taking place during a period of unprecedented momentum in Africa's space sector, with new national space agencies emerging in Senegal and Uganda, strengthened leadership in Egypt, Nigeria and South Africa, and the operationalization of the African Space Agency (AfSA), the workshop focused on the theme "United for Africa" and addressed systems engineering, project management, mission best practices, NewSpace dynamics, and trends in space technology and data applications.

The workshop convened 50 participants including IAF VP for Membership Development and Financial Matters - Michal Brichta, IAF VP for Emerging Space Ecosystems - Gaspard Twagirayezu, IAF ACCESS Africa Subcommittee Leadership and members, representatives of Envoy Initiative partner countries such as Senegal, Zimbabwe, Cameroon, Ethiopia and Libya, as well as space agencies and regional actors from across the continent including Senegal, Morocco, Ethiopia, Egypt, Algeria, Cameroon, Mauritius, Rwanda, Gabon, Ghana, Kenya, Nigeria, Burkina Faso and Tanzania.

Opening the session, Fama Jallow welcomed participants and outlined the workshop's thematic priorities, emphasizing the growing need for coordinated engagement to

support Africa's emerging capabilities. **Charles Aimé Nzeussi Mbouendeu**, Chair of the IAF ACCESS Africa Subcommittee, highlighted the subcommittee's ongoing outreach, participation in international events, and the need-driven design of the Envoy Initiative, shaped through tailored engagements with African partner countries.

His remarks were followed by an intervention from IAF VP **Michal Brichta**, who underscored the IAF Envoy Initiative's role as a bridge between emerging space nations and the global space community, noting that Africa is presently the most active region within the programme.

In his address, **Gaspard Twagirayezu**, CEO of the Rwanda Space Agency (RSA) and IAF Vice President for Emerging Space Ecosystems, expressed optimism about Africa's accelerating space ambitions, crediting space technology for its growing role in socioeconomic development, resilience building and competitiveness. He emphasized Rwanda's alignment with IAF's vision and announced that Kigali will host the IAF Global Space Conference on Climate Change (GLOC 2026) from 2 to 4 June 2026, inviting stakeholders to contribute to a platform intended to strengthen innovation, partnerships and Africa's global presence in space discourse.

Additional technical presentations deepened the workshop's focus. **Davis Cook** examined the rapidly evolving global space economy, noting dramatic reductions in launch costs and the shift toward industrialized "Space 2.0" production, which he argued creates new opportunities for African nations to enter high-volume manufacturing and operations markets. **Meshack Kinyua Ndiritu** provided an overview of AfSA's evolution, governance and strategic priorities, outlining Africa's growing but uneven space ecosystem and the need for coordinated continental programmes that strengthen local capacity and private-sector participation. **Andre Pliewischkies** discussed project management and knowledge management for space missions, emphasizing the importance of established standards, clear requirements, and organizational cultures that prioritize knowledge sharing. **Ifriky Tadadjeu** expanded on mission management practices, describing the V-model process, the increasing use of agile methods, and the human-centered leadership required to manage diverse technical teams and ensure mission success.

The discussions underscored shared ambitions across African stakeholders and reaffirmed the central role of structured capacity-building in shaping a sustainable and competitive African space future. The workshop established a solid foundation for deeper technical training planned for early February 2026.

The IAF, through the Envoy Initiative and its regional subcommittees, committed to continuing targeted engagements, supporting institutional development, and ensuring that African nations play an active and influential role within the global space ecosystem.

IAF Astrodynamics Committee

Introduction

The IAF Astrodynamics Technical Committee promotes advances in orbital mechanics, attitude dynamics, guidance, navigation and control (GNC) of single or multi-spacecraft systems, as well as space robotics. The IAF Astrodynamics TC was established more than four decades ago and currently includes approximately 30 experts from academic and research institutions, industries and space agencies. The IAF Astrodynamics Symposium is coordinated by the TC and conducted annually during the International Astronautical Congress (IAC).

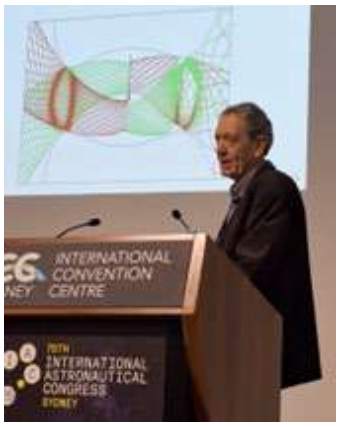
Summary

This year's research in astrodynamics includes a continued focus on trajectory design and GNC to and around the Moon, employing both novel and classic techniques. Topics include low-energy and low-thrust trajectories, cislunar traffic management, autonomous navigation and rendezvous in cislunar space, and transfers between Near Rectilinear Halo Orbits and Low Lunar Orbits or Sun-Earth libration point orbits. Other areas of interest include trajectory design, attitude control, and GNC for on-orbit servicing missions, both in Earth orbit and in cislunar space, as well as GNC for rendezvous, proximity operations, docking, and imaging with cooperative and non-cooperative targets. In addition, the application of AI techniques is a primary focus. Topics include AI-aided algorithms for GNC and formation flight, reinforcement learning for design of multiple gravity assist trajectories, and automatic initialization of low-thrust trajectory optimization tools. Research also includes a focus on GNC and trajectory design for smallsats. Of particular interest is launch ridesharing for reduced-cost access to space for small missions, including piggy-back launches with LEO spacecraft for smallsats with beyond-Earth-orbit destinations. Dynamics and control of lunar constellations for communication, navigation, and remote sensing is another primary topic of study. Additional areas of focus include the transition of multibody trajectories into higher-fidelity models, as well as mission design to asteroids and comets.

Highlights

- The joint ESA and JAXA mission BepiColumbo successfully performed its sixth Mercury flyby on 8 January 2025, with a close approach altitude of 295 km. Mercury orbit insertion is planned in 2026.
- The commercial Hakuto-R mission (ispace) launched on a rideshare with the commercial Blue Ghost Mission 1 (Firefly Aerospace) on 15 January. Hakuto-R successfully completed a lunar flyby on 15 February that inserted the spacecraft onto a low-energy transfer to lunar orbit. Employing solar gravity to raise perigee, Hakuto-R achieved lunar orbit on 6 May. The attempted lunar landing resulted in impact on 5 June.
- After launching with Hakuto-R, Blue Ghost Mission 1 performed a 25-day set of Earth phasing orbits, followed by a 4-day direct transit to lunar orbit. After 16 days in lunar orbit, Blue Ghost successfully landed on 2 March and completed a 14-day lunar mission.
- The commercial IM-2 Mission (Intuitive Machines) launched on 27 February and performed a direct transit to the Moon, successfully entering lunar orbit on 3 March. Its landing on 6 March resulted in an incorrect attitude on the Moon.
- ESA's Solar Orbiter performed its fourth Venus gravity assist on 18 February, increasing inclination from 7.7° to 17°. The spacecraft will perform its fifth Venus gravity assist on 24 December, further increasing inclination to 24°. The inclination increases are designed to enable views of the Sun's polar regions.
- NASA's Europa Clipper launched on the opening day of IAC-2024 on 14 October 2024. It successfully performed a Mars flyby on 1 March 2025, setting up a future Earth gravity assist to aid in reaching Europa in 2030.
- ESA's HERA mission successfully performed a Mars flyby on 12 March, including a 300 km altitude flyby of Deimos, setting up its arrival at the asteroid Didymos scheduled in December 2026.
- NASA's Lucy spacecraft performed a flyby of asteroid 52246 Donaldjohanson on 20 April at an altitude of 922 km, the second of eight planned asteroid flybys during its twelve-year primary mission.
- NASA's Parker Solar Probe completed its 23rd, 24th, and 25th perihelion passages on 22 March, 19 June, and 15 September respectively, reaching a speed of 191 km/s relative to the Sun at an altitude of 6.1

million km. It will perform its 26th perihelion passage on 24 December.
- ESA's Juice mission successfully performed a gravity assist at Venus on 31 August, with a flyby altitude of 5088 km. The Juice spacecraft will perform a pair of Earth flybys in 2026 and 2029, arriving at Jupiter in 2029.
- In future plans, the Emirates Mission to the Asteroid Belt (EMA) will launch in 2028 and perform a Venus gravity assist to set up a flyby of 7 asteroids in the main belt using electric propulsion. A lander will be released from the spacecraft to impact Justitia, the last asteroid of the tour.



Future Outlook

Looking ahead, increased computational capabilities will enhance autonomy of spaceflight operations. In particular, autonomous operations in constellations, including navigation, collision avoidance, and reconfiguration, will be important, and autonomous operations in cislunar space, including navigation and rendezvous/docking will continue to be of interest. The miniaturization of spacecrafts with cubesats and smallsats can lead to lower costs for development and launch of satellites, though often GNC and trajectory design are more, not less, challenging for smaller spacecraft. An increased pace of investigation into AI-aided algorithms for GNC, formation flight, and low-thrust trajectory design and optimization is expected.

Committee activities

The John V. Breakwell Memorial Lecture at IAC25 was delivered by Prof. Josep Masdemont (Universitat Politecnica de Catalunya– Spain) during the Mission Design, Operations & Optimization (1) session of the Astrodynamics Symposium. Prof. Masdemont is a pioneer of libration point orbit dynamics, including the use of invariant manifolds for low-energy trajectory design. The title of his Breakwell Memorial Lecture was "Libration Point Orbits: A Brief Journey Through Fundamental Dynamics and Applications."

Upcoming conferences include the following events:

- Spacecraft Mission Operations SMOPS 2026 to be held in Bangalore India on 8-10 April 2026
- International Symposium on Spaceflight Dynamics (ISSFD) to be held in Toulouse in May/June 2026
- The 2nd IAA Latin America Conference will be held in Salta, Argentina on 1-6 June, 2026.
- The COSPAR conference to be held in Florence, Italy in July 2026 will include a special session (A0.1) on open scientific problems regarding the tropics; Earth observation challenges can be addressed with smallsats. The call for abstracts opens in November 2025.

IAF Earth Observations Committee (EOC)

Introduction

Earth Observations continue to expand their impact in 2025, with global recognition of their role as essential infrastructure for resilience, security, and sustainable development. The convergence of climate change, disaster risk, and biodiversity loss has intensified demand for timely, high-resolution, and actionable data. At the same time, rapid progress in satellite constellations, cloud-based geospatial platforms, and advanced analytics is transforming EO into a service domain accessible well beyond traditional space actors.

The integration of Artificial Intelligence (AI), Machine Learning (ML), and Digital Twins is accelerating the ability to extract knowledge from massive and diverse

EO datasets, enabling predictive insights for climate adaptation, agriculture, water management, health, and urban resilience. These tools are increasingly coupled with in-situ and non-space technologies, creating hybrid observation systems that enhance both local and global decision-making processes.

The EO ecosystem itself is evolving, marked by the rise of agile private companies, new forms of public-private partnerships, and multi-stakeholder coalitions. Governments continue to invest in strategic EO missions, but industry and civil society are playing a larger role in shaping innovation, policy, and user engagement. Importantly, inclusivity and capacity-building remain central-ensuring that EO benefits extend to developing nations and vulnerable communities.

As Earth Observations enter this new phase, the International Astronautical Federation (IAF) Earth Observations Committee remains a platform for collaboration across scientific, governmental, commercial, and societal domains, advancing the shared goal of transforming EO data into global resilience and opportunity.

Summary

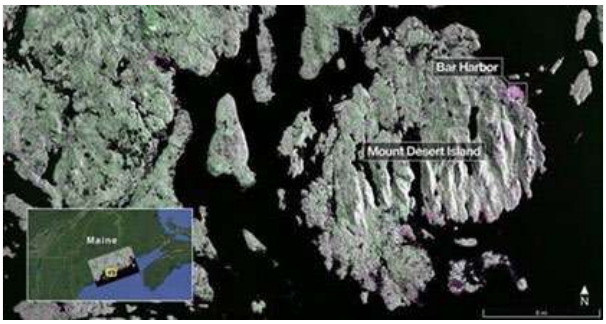
EO as a core element of national security. In the past year, Earth Observations have become a core element of national security strategies worldwide. Governments are no longer purchasing only data – they are acquiring end-to-end EO systems as assets, ensuring independence in intelligence, border monitoring, disaster response, and infrastructure protection. The priority is placed on secure, autonomous EO capabilities. As dual-use satellites increase rapidly, EO has solidified its role as both a strategic defense tool and a driver of global resilience.

EO companies are adjusting their strategies. Earth Observation (EO) companies are shifting their focus from data sales to satellite or satellite system sales to cater to the changing needs of global markets, which is opening new avenues for growth, unforeseen only a few years ago. [Satellite Today: *Geopolitics Drive Shifts in EO Business as Companies Hone Focus on Defense Market*]

Uncertainty at NASA. Recent comments by NASA's Acting Administrator have created uncertainty about the future of Earth science programs at the space agency which has been a core part of the work of the Agency since its inception. "All of the climate science and all of the other priorities that the last administration had at NASA, we're going to move aside," he said. "All of the science that we do is going to be directed towards exploration, which is the mission of NASA. That's why we have NASA, is to explore, not to do all of these Earth sciences." [SpaceNews: *Duffy comments seed doubts about future of NASA Earth science*]

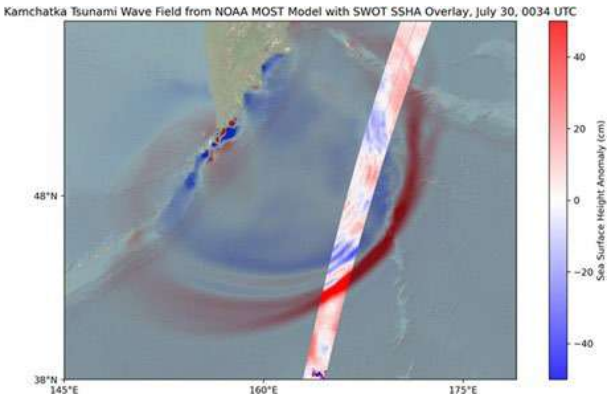
Highlights

First Light Image NISAR Launch and Deployment a Roaring Success Image from NISAR's L-band radar shows Maine's Mount Desert Island (Credit: NASA/JPL-Caltech) The NASA-ISRO Synthetic Aperture Radar (NISAR)



Spacecraft was launched successfully on 30 July 2025, then deployed its 9m boom, and 12 m diameter reflector. The L band radar electronics were turned on and first light images were obtained. To date, everything is working seamlessly. Commissioning takes about 90 days and then NISAR will move into the Science Operations phase. All NISAR data products will be made available freely and openly at the Alaska Satellite Facility (ASF) Distributed Active Archive Center (DAAC) (https://search.asf.alaska.edu) once the project team is comfortable with the preliminary calibration, which we anticipate in the coming weeks.

SWOT image catches Tsunami
The SWOT satellite captured a tsunami in July 2025 following a major earthquake off Russia's Kamchatka Peninsula. The satellite provided a detailed view of the tsunami's leading edge, measuring its height, shape, and direction, which helps scientists improve tsunami forecast models. This observation demonstrates SWOT's ability to monitor hazardous events and potentially improve early warning systems for coastal communities.



The US-French SWOT satellite caught the leading edge of a tsunami wave (red) after a massive earthquake near Russia on July 30. The basemap is the prediction by NOAA of the tsunami. (Photo Credit: NASA/JPL-Caltech)

NOAS Luxembourg successfully placed its first national Earth observation satellite into orbit on 26 August 2025,

aboard a SpaceX Falcon 9. Built by OHB Italia S.p.A., NAOS supports applications including military operations, treaty monitoring, disaster management, climate change, humanitarian aid, and land administration. Equipped with Elbit Systems' Jupiter space camera, it delivers panchromatic, RGB, and near-infrared imaging, with data shared with Luxembourg's institutions and international partners such as the EU, NATO, UN, and IAEA.

Dror-1 Successfully launched in July 2025 aboard SpaceX Falcon 9. Developed as part of Israel's national communications satellite program, Dror-1 ensures secure and independent satellite communications. It also features additional payloads for selfie imaging and Earth Observation. See the following image:

Ofek-19 successfully launched in September 2025 on the Shavit launcher. Built by Israel Aerospace Industries (IAI) for the Israeli Ministry of Defense, Ofek-19 is part of Israel's national satellite program. This synthetic aperture radar (SAR) observation satellite is designed to provide advanced high-resolution imaging, enhancing Israel's intelligence, surveillance, and national security capabilities.

CNES/Airbus CO3D The Airbus-built CO3D (Constellation Optique 3D) satellites have been successfully launched in July 2025 into SSO orbit aboard Vega-C rocket. Developed in partnership with CNES the four satellites are set to begin delivering a highly detailed 3D map of Earth's surface. These dual-use satellites are designed to produce global high-resolution Digital Surface Models (DSMs), capturing 50 cm stereo imagery for CNES and 2D imagery for both government and commercial customers. The mission reinforces Airbus's portfolio of advanced optical and radar satellite systems.

CNES MicroCarb scientific mission was successfully launched from the European Spaceport in Kourou, French Guiana. A joint collaboration between France and the UK to map, on a global scale, the sources and sinks of carbon dioxide; the main greenhouse gas caused by human activity. It is the first European mission to monitor and map atmospheric carbon dioxide. MicroCarb will show how space-based science can improve our understanding of the vital carbon cycle and contribute to informed climate policy decisions to help protect our planet. Thales Alenia Space was responsible for the assembly, integration and testing of the satellite platform as well as launch preparations.

JAXA GOSAT-GW Japan's Global Observing SATellite for Greenhouse gases and Water cycle (GOSAT-GW), a follow-on mission to GCOM-W and GOSAT-2, was launched aboard a H-IIA rocket from Tanegashima Space Centre on 29 June 2025. It carries two instruments: TANSO-3, for measuring atmospheric greenhouse gases, and AMSR3, for monitoring key water cycle variables including precipitation, sea surface temperature, and soil moisture.

ESA Living Planet Symposium 2025 ESA's 2025 Living Planet Symposium (LPS) took place in June in Vienna, Austria. Held every three years, LPS is one of the world's premier events in Earth observation (EO). This year 6,900 participants from 125 countries took part.

ESA Biomass Biomass, ESA's forest-mapping satellite, was launched on a Vega-C rocket from Kourou, French Guiana, on 29 April 2025. It carries the first space-based P-band Synthetic Aperture Radar (SAR) and offers fully polarimetric measurements to derive forest biomass and carbon stocks in three dimensions.

ESA/EUMETSATMTG MTG-S1 (Meteosat Third Generation - Sounder), part of Europe's series of third-generation geostationary meteorological satellites, was launched aboard a SpaceX Falcon 9 rocket from NASA's Kennedy Space Centre on 1 July 2025. Alongside the Infra-Red Sounder from which MTG-S1 takes its name, the satellite also hosts the Sentinel-4A payload, an imaging spectrometer that will monitor air quality over Europe by measuring aerosols and trace gases like nitrogen dioxide and ozone. Thales Alenia Space is responsible for the development, assembly, integration and testing of the main payload..

ESA/EUMETSAT MetOp-SG A new era of weather and climate monitoring from polar orbit, the first in a new series of satellites, MetOp Second Generation, has been lofted into orbit in August 2025. As part of the satellite's instrument package is the new Copernicus Sentinel-5 instrument, which is designed to deliver critical data on air pollutants, ozone and climate-related gases.

ESA SIRIUS mission study contract. It aims to observe European cities from space using thermal infrared (TIR) data products, which allow the measurement of the temperature of objects from a distance. The objective is to understand how Urban Heat Islands modify the local climate.

ESA/EC COPERNICUS Sentinel-1D will lift off on November 4th from Europe's Spaceport in Korou, ensuring the continuity of services on which a wide range of end users rely worldwide. Sentinel-1D has a C-band synthetic aperture radar (SAR) instrument on board, which allows it to capture high-resolution imagery of Earth's surface. This

powerful radar system operates in several modes, including wide swath and high-resolution, providing detailed data on land subsidence, ice movements and ocean conditions.

Norway NORSAT-4, the Norwegian maritime monitoring microsatellite, launched on the SpaceX Transporter-12 rideshare mission on14 January 2025. The satellite carries an AIS receiver as well as a novel Low Light Imager. The latter is capable of detecting ships longer than 30 meters, even during periods of darkness or under poor lighting conditions.

ROSKOSMOS Kondor-FKA N2, an S-band Synthetic Aperture Radar (SAR) mission, launched on 29 November 2024. The ROSKOSMOS mission will monitor disasters, the sea surface, and environment, with a particular focus on sea ice measurements. The satellite is operating in a sun-synchronous orbit, at an altitude of 510 km and inclination of 97.4°.

ISRO's RISAT-1B, also known as EOS-09, was launched on 18 May 2025, aboard the PSLV-C61 rocket, carrying a C-band SAR. The mission failed due to an anomaly in the rocket's third stage, preventing the satellite from reaching orbit.

MBZ-SAT and Etihad-SAT MBRSC releases first images from MBZ-SAT, Etihad-SAT. MBZ-SAT, launched in January 2025, is the region's most advanced satellite using optical imaging, while Etihad-SAT, launched in March 2025, is MBRSC's first Synthetic Aperture Radar (SAR) satellite capable of capturing data in all weather and lighting conditions. Together, the satellites deliver consistent, high-resolution data to support key sectors such as disaster management, smart agriculture, and infrastructure development.

France Security & Defence CSO-3 optical Earth-observation satellite successfully launched. CSO-3 will provide increased coverage and revisit capabilities to enable more effective conduct of military operations and faster crisis response.

Commercial:

- **NIBE EO Constellation contract award**, for the deployment of India's first private Earth Observation constellation.
- **NAOS (National Advanced Optical System), Luxembourg's dual-use** observation satellite system, capable of acquiring imagery at 0.5 m resolution;
- **Pelican-3,4 from Planet**, the company's very high-resolution imaging satellites with onboard processing, capturing at 0.3 m resolution;
- **Acadia-6 from Capella Space** (acquired by IonQ), continuing launch of its next-generation SAR satellite, capturing data at 0.5m;
- **FFLY-1,2,3 from Pixxel**, joining the first three satellites launched in January and completing the company's first phase of its operational constellation;
- **LEAP-1 from Dhruva Space**, which hosts two EO payloads from Australian startups Akula Tech with onboard processing unit and OTR-2 by Esper Satellites with a hyperspectral imager.

Outlook

Integration of EO AI foundation models into geospatial analytics Earth Observation field is entering a new phase shaped by the integration of AI foundation models into geospatial analytics. These large-scale AI systems, trained on multimodal EO and in-situ data, will enable more accurate forecasting, cross-domain insights, and near-real-time decision support. Their ability to generalize across sensors, regions, and applications represents a breakthrough in transforming raw EO data into actionable knowledge. In the coming years, a major focus will be on applying these capabilities to Early Warning Systems (EWS). By coupling EO foundation models with climate, hydrological, and socio-economic data, it will be possible to deliver earlier, more precise, and more accessible warnings for hazards such as floods, droughts, wildfires, and epidemics. This shift aligns with the UN's Early Warnings for All initiative and will enhance resilience in vulnerable regions. These trends point toward a future where EO becomes an intelligent, predictive infrastructure – not just observing Earth, but helping humanity anticipate and shape its response to global challenges.

The rise of VLEO 2025 marks also the start of the Very Low Earth Orbit (VLEO) and Very Very High Resolution (VVHR) era, set to disrupt competition going forward. The Chinese Chutian constellation deployed its first prototype in 2024 and is preparing for larger deployment this year. In the US, commercial players have also started deployment, signaling a new generation of high-resolution, low-latency capabilities. Operating at lower altitudes than traditional satellites, VLEO satellites offer benefits like reduced launch costs and enhanced resolution. Advances in propulsion and AI are enhancing satellite capabilities for applications such as broadband internet, environmental monitoring, and security. Key players, including Sierra Space and Redwire, are at the forefront of this competitive landscape, integrating advanced technologies. As the market grows, challenges such further overcoming atmospheric drag and regulatory compliance will demand attention.

It is widely acknowledged that EO will continue to be a critical enabler for a better way of life, and better societies, hence one can well expect **the value of EO as a public good will only continue to grow.**

Committee Activities

International Astronautical Congress (IAC 2025) marked the first full year of the new IAF Earth Observations

Committee (EOC) Chair team (2025-2027). With a 3-point focus on: (i) further operationalising the committee activities, (ii) growing its Comms and Outreach, and (iii) deploying a tailored approach for membership growth, the first year has been a promising one.

IAC 2025 A successful IAC in Sydney took place in Fall 2025 with the conference featuring 8 EO-dedicated Technical Sessions, a Plenary, and Special Sessions coordinated or supported by the IAF EOC. For 2026, a new permanent session B1.8 addressing the emergence of AI and EO Foundation models across the EO value chain has been proposed.

On July 10. 2025, the IAF Earth Observation Committee has participated in the IAF Technical Committees Webinar Series with the IAF. You may rewatch it under this link.

The IAF Earth Observations Committee at IAC 2025 Sydney, Australia

IAF Knowledge Management Committee

Informing the Future, Maintaining a Legacy

Introduction

The work of the international aerospace community relies on remarkable people, innovative ideas, and effective processes to advance a project from concept to reality. Underlying all of this is a core knowledge infrastructure that helps people and organizations to learn together and share knowledge effectively with one another. Knowledge management supports all disciplines and activities of the international aerospace community, shepherding expertise and providing insights to advance projects, disciplines, and collaboration approaches based on lived experience.

The International Astronautical Federation (IAF) Knowledge Management Technical Committee (KMTC) seeks to promote and facilitate discussions for knowledge capture/sharing amongst organizations and industries conducting space-related activities and promote the adoption or sharing of standards, methods, processes and tools that support the sharing of data, information, and knowledge related to space missions. As digital technology affords greater capabilities, the work of the IAF KMTC and its members has become ever more relevant and timely in improving the performance of missions across established and emerging members of the aerospace community.

Summary

Effective knowledge management ensures that critical knowledge is maintained and sustained across geographic and disciplinary boundaries and across multiple generations of the aerospace workforce. In the past year, aerospace organizations have made important strides in knowledge management techniques, contributing to the broader discipline and supporting important work by space organizations. Significant development and trends in the knowledge management field include greater engagement with artificial intelligence for knowledge discovery, analysis

and curation; new methods to strengthen connections and build relationships for knowledge sharing within and among organizations; and improved understanding of the ways in which knowledge management practices correlate to improved mission results. This work is exemplified in presentations at the International Astronautical Congress (IAC), as well as benchmarking discussions among members and guests of the KMTC.

Highlights

The field of knowledge management interrelates with the artificial intelligence, data science, and information management fields, as well as more traditional discipline partners such as information architecture and organizational development. Knowledge management has extensive applications in many fields outside of the aerospace sector; wherever organizations develop knowledge and seek ways to improve its application and their overall performance, knowledge management has a place. New developments and innovations in the application of knowledge management practices within the aerospace community relate to the use of digital technologies, broadened applications, and increased collaboration among aerospace partners.

As knowledge management activities increasingly take advantage of artificial intelligence capabilities, the capacity and possibility for the application of knowledge management across organizations and disciplines also increases. Where artificial intelligence can reduce the time required for collection and coarse analysis of information, for instance, knowledge management practices can complement artificial intelligence by encouraging deep thinking and connection among related areas of expertise. These practices are observed in mature and emerging space organizations. Various case studies describe ways of applying Large Language Models for knowledge discovery, use of generative artificial intelligence to collect and organize data and information to inform decision-making, and applications of retrieval-augmented generation to support complex inquiries. Knowledge management practices to develop ontologies remain relevant and find new applications with artificial intelligence and related digital technologies. These highlights of knowledge management practices that are better informed through artificial intelligence show how knowledge management as a field continues to evolve and embrace new potentialities.

Knowledge management practices have long been applied in a wide range of aerospace disciplines and domains. With the introduction of new technologies, knowledge management is now being applied in the aerospace industry to inform policy determinations and assess consensus among partners. Other research shows how knowledge management practices can enhance the development and application of aerospace technologies, using evidence-based practices to evaluate the advantages knowledge management affords. These new applications reinforce the value of knowledge management practices and suggest different dimensions for consideration.

Collaboration is vital for the aerospace community. Knowledge management innovations that support effective collaboration and transparency build trust and encourage partnerships. For example, some practitioners are rethinking knowledge management applications to focus more deeply on facilitating exchange workshops and providing opportunities to build connections among the workforce. Many aerospace organizations encourage participation in knowledge sharing forums, courses, and activities to improve the likelihood of successful collaboration. New innovations in collaboration through in-person, remote, and hybrid dialogues are advanced with the support of knowledge management infrastructure and guidance from experienced knowledge managers.

With changes to the aerospace workforce and new entrants into the aerospace market, knowledge management continues to play an important role in facilitating and bringing about successful partnerships and projects. Highlights from the knowledge management field are well demonstrated across the aerospace community.

Outlook

The future of the knowledge management discipline is extraordinarily promising.

Broader collaboration practices and more robust information technology and artificial intelligence capabilities enable more intuitive and relevant knowledge sharing capabilities, so that insights are readily available to those who need them and are more easily captured and processed. Research in this area is flourishing and generative.

The IAF KMTC also anticipates a greater interest in the results of knowledge management activities. Which knowledge management interventions deliver the most impactful results? Research demonstrating how knowledge management improves performance and which elements are most easily replicated is of special interest to this community.

One especially interesting area in the practice of knowledge management is how new organizations learn from mature organizations. When are lessons learned relevant? Which knowledge is important to transfer? As new organizations are created and join the aerospace market, the IAF KMTC looks to learn more from their practices and consider how their practices might be adopted for organizations with lengthier histories.

Overall, the myriad different approaches to knowledge management have created a wide range of new areas to learn and advance innovation and research in the knowledge management discipline, which is expected to continue for many years.

Committee activities

The IAF Knowledge Management Technical Committee will continue to engage members in regular benchmarking discussions and foster collaboration among members in areas of similar interest. KMTC appreciates a close partnership with the International Project/Programme Management Committee, mentoring the Young Professionals Workshop and proposing a new technical session for IAC 2026.

IAF Materials and Structures Committee

Introduction

The International Astronautical Federation (IAF) Materials and Structures Committee was established more than three decades ago. The Materials and Structures Symposium, coordinated by the Committee, provides an international forum for discussing recent advancements and assessment of the latest technology achievements in space structures, structural dynamics, and materials, particularly in relation to space transportation, space vehicles, and orbital infrastructures. Currently, the IAF Materials and Structures Committee has approximately 40 members, with at least 30 actively involved in the annual organization of the International Astronautical Congress (IAC).

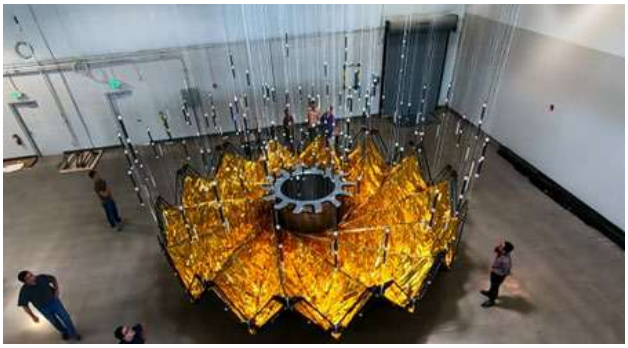
Summary

As in the entire space sector, the field of materials and structures is undergoing constant evolution and advancements. Over the last years, there has been a growing trend towards further miniaturization of satellites and the development of small launchers has been observed. Cost-efficient, sustainable and reusable space transportation solutions, as well as in orbit manufacturing and assembling technologies, have been discussed as prerequisite for the commercial use of the low Earth orbit (LEO) ecosystem. Lightweight design is continuously evolving through the use of new materials, new production technologies, and advancements in computational optimization methods. The evolution of the Clean Space Initiative has been observed, featuring advancements in efficient structures, mechanism designs as well as robotic orbital support services. Eco-friendly designs and reusability are key factors in promoting clean space.

Highlights

Deployable and dimensionally stable structures:

The key technical developments in the field of deployable and dimensionally stable structures over the last year highlight both technological maturity and disruptive innovations. Origami-inspired and inflatable designs continue to enhance compactness and deployment reliability and are now integrated with novel compliant hinges and shape-memory alloy actuators, which simplify mechanisms while increasing robustness. These approaches are being advanced for large observatories and Starshade missions, supported by breakthroughs in nano metrology and edge-control sensing that enable sub-millimeter accuracy over tens of meters. Small satellite platforms have also benefited from innovation, with DCUBED's off-the-shelf deployable, demonstrating that scalable solar arrays and antennas can transition from CubeSat to flagship missions. Among large systems, the 14.2-metre solar arrays of NASA's Europa Clipper, launched in 2024, represent the largest interplanetary panels ever built. In addition, on 29 August 2024, the ACS3 solar sail successfully deployed its 80-square-metre membrane in orbit, a significant breakthrough for lightweight composite booms and membrane tensioning. In early 2025, new inflatable Starshade prototypes demonstrated reliable 10–15 meter deployments, while the first robotic ISAM assembly trials validated autonomous joining and digital-twin-guided verification of modular truss structures. These breakthroughs point to a paradigm shift: deployable are no longer constrained by fairing volume but can be adaptively built, stabilized, and verified in orbit, combining ground testing, predictive modelling, and in-situ sensing into a single hybrid verification framework.



Starshade. Credits: NASA.

Space Structures and Materials for Extreme Environment:

Advanced materials and structures designed for extreme temperature applications are essential for the storage of

cryogenic propellants. Applications for space transportation and long-term storage require efficient thermal insulation.

Applications in the hypersonic range of the re-entry require efficient high-temperature resistant materials. This includes carbon-carbon and ceramic matrix composites, ultrahigh temperature-resistant ceramics, ablative materials, ceramic tiles, and other passive or active insulation concepts. Together, these materials and innovative structural concepts are vital for propulsion systems, launchers, hypersonic vehicles, entry vehicles, aero-capture and power generation. The full spectrum of material, design, manufacturing and testing aspects needs to be mastered.

Recently, interest in reusable launchers or stages has significantly increased, partly due to the emergence of various mega-constellations that require multiple launches. This demand has triggered new developments in innovative thermal protection systems and cryogenic insulation, focused on partial or complete reusability. Additionally, the renewed trend in space exploration toward the Moon, Mars, Ice Giants, and other planetary bodies is creating a need for materials that can withstand diverse and challenging environments in terms of temperature, pressure, and gas composition.

Thermal control:

Thermal control of spacecraft is always a challenging topic, not only for satellites but also for launcher upper stages with long ballistic phases.

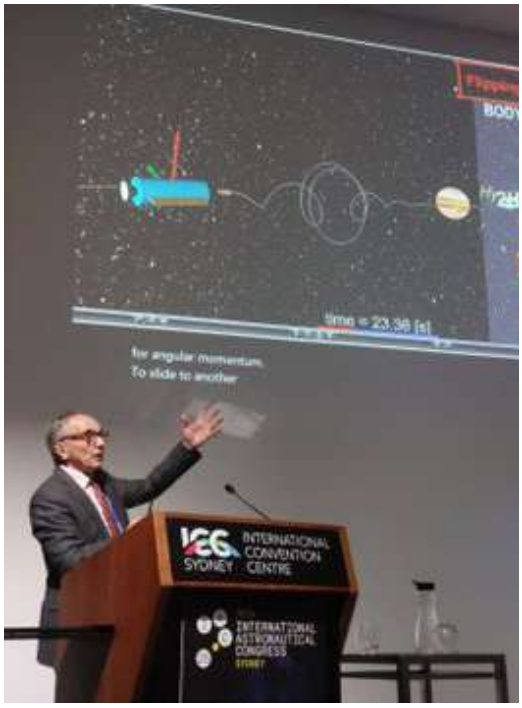
Current research performed at the Moscow Aviation Institute on spacecraft thermal control systems promotes new types of heat pipes that can function effectively in any geometric position, both in the field of gravity and in zero gravity.

Outlook

New challenges and solutions in the industrialization of the launcher and spacecraft industry are emerging, driven by the seamless integration of digitalization, automation versatility, and artificial intelligence (AI). This convergence of technologies is propelling a new era of efficiency, reliability, and innovation, reshaping the design, manufacturing, and operation of launch vehicles. It promises to redefine the capabilities and economics of accessing space amid intense competition. A keynote on this topic has been given by Jean-Matthieu Guimard from ArianeGroup in the new session C2.7 of the IAF Materials and Structures Committee during the IAC in Milan in 2024.

Continuous development of new technologies (including miniaturization of electronic hardware, introduction of new materials) allows significant reduction of the mass of satellites. However, this reduction is in conflict with heavy mass and complexity of the modern attitude control systems, employing gyroscopes. An attractive alternative of controlling spacecraft without employment of the traditional gyroscopic devices has been proposed by Prof. Dr. P.M. Trivailo from RMIT in Australia. It involves deliberate changes of the inertial properties of the system, called “Inertial Morphings (IM)”, used for control of the attitude of the spacecraft. “Inertial Morphing” control concept is essentially based on realization that the spinning spacecraft can be seen and utilized and gyroscope itself, instead of utilization of complex, heavy and energy-consuming gyroscopic devices on-board. It has been recently discovered and demonstrated via versatile numerical simulations, that IM can be used to enable spacecraft with wide range of attitude control capabilities.

At the International Astronautical Congress in 2025 (IAC 2025), Prof. Dr. P.M. Trivailo has received the Paolo Santini Memorial Lectures Award. Prof. Trivailo has held an extraordinary Paolo Santini Memorial lecture related to Inertial Morphing, its theoretical background and it applications for spacecraft attitude control.



Committee Activities

The technical presentations presented at the Materials and Structures Symposium during the IAC 2025 have consistently attracted a large audience within the scientific community, making the Symposium one of the most popular at the Congress. In the coming year, the IAF Materials and Structures Committee will propose some initiatives to engage researchers and engineers from new emerging countries in the aerospace sector. One way to do this is the participation to the WD/YPP webinars.

Iaf Committee On Planetary Defense (Pd) and Near-Earth Objects (Neos)

Introduction

Planetary defense refers to the array of scientific, technical, and institutional capabilities required to detect, characterize, and monitor asteroids and comets that may pose a potential impact threat to Earth, and to develop and implement measures aimed at preventing or mitigating their possible consequences. A Near-Earth Object (NEO) is defined as an asteroid or comet whose orbital path brings it within approximately 45 million kilometers of Earth's orbit. The IAF Technical Committee (TC) on Planetary Defense and Near-Earth Objects seeks to advance global understanding and awareness within the space community by fostering dialogue, collaboration, and outreach across disciplines. Its principal mission is to promote planetary defense initiatives, particularly among participants of the Intrenational Astronautical Congress (IAC), and to encourage and support greater engagement from the next generation of researchers, students, and young professionals in the field.

Summary

The past year 2024-2025 included several key developments in planetary defense. On 1 August 2024, the Space Mission Planning Advisory Group (SMPAG) initiated a hypothetical Near-Earth Asteroid impact exercise *"2024PDC25"*, conducted in connection with the Planetary Defense Conference (PDC) 2025 scenario. The exercise involved coordinated participation from SMPAG members and generated broad discussion within the community.

In October 2024, ESA's Hera mission was launched toward the Didymos-Dimorphos system to obtain post-impact observations following NASA's 2022 DART mission.

In December 2024, the discovery of asteroid 2024 YR4 led to short-term concern when early orbital calculations indicated a Level 3 on the Torino Scale. Subsequent international follow-up observations refined the orbit and confirmed that no impact threat existed. That same month a resolution was adopted by the United Nations designating the year 2029 as the "International Year for Asteroid Awareness and Planetary Defence 2029 (IYAPD2029)".

In January 2025, ESA's RAMSES mission concept completed its Preliminary Design Review, advancing plans for a rapid-response probe to rendezvous with Apophis before its 2029 close approach.

In April 2025, international researchers met in Tokyo for joint workshops on Hera, RAMSES, and Apophis T-4 to coordinate planning activities. In May, the ninth IAA Planetary Defense Conference took place in South Africa, featuring a new hypothetical impact scenario for testing response procedures. By July 2025, SMPAG established an ad hoc working group on Apophis to be coordinated by COSPAR. In September, NASA's OSIRIS-APEX mission completed its Earth gravity-assist maneuver en route to Apophis, and ESA and JAXA presented their collaboration on the RAMSES mission at the IAC. During the same period, the Rubin Observatory reported its first series of asteroid detections.

These activities collectively reflect the continuation of coordinated international efforts to strengthen detection, response planning, and mission development related to near-Earth objects and to the growing field of planetary defense.

Highlights

Over the past year, notable developments in near-Earth object research and planetary defense included the detection of a potential Earth impactor that activated international notification protocols before being ruled out as a threat, the first use of the James Webb Space Telescope (JWST) to observe a potential impactor, a key mission milestone in ESA's Hera mission to the Didymos system, and the expansion of NEO observation capabilities at the Purple Mountain Observatory.

On 27 December, 2024, the ATLAS sky survey discovered a previously unknown asteroid designed 2024 YR4. As

additional telescopic data accumulated, the probability that 2024 YR4 would impact Earth increased and reached 1% for 2032. Given that the threshold proposed by the International Asteroid Warning Network (IAWN, iawn.net) for issuing warnings of possible impact effects is a probability of impact greater than 1% and a rough size estimated to be greater than 10 meters, on 29 January 2025, IAWN issued a notification to the United Nations Office of Outer Space Affairs about a potential asteroid impact on Earth on 22 December 2032. Observations of 2024 YR4 continued, and on 24 February 2025, IAWN issued a notification stating that Earth impact had been ruled out. This asteroid, 2024 YR4, marked the first time that IAWN issued a notification about a real potential Earth impactor, as opposed to a hypothetical one. Many lessons were learned as a result of this real-world event. As of this writing, there is still a ~4% probability that YR4 will impact the Moon in 2032. The asteroid will become observable again in 2028.

When asteroid 2024 YR4 was first discovered, little was known about its physical characteristics. Initial estimates placed its size between 40 and 90 meters, resulting in substantial uncertainties regarding the potential effects in the event of an Earth impact. Recognizing the need for better information about the asteroid's size, a team led by Andy Rivkin of the Johns Hopkins University Applied Physics Laboratory proposed to observe 2024 YR4 with the James Webb Space Telescope. That proposal was selected, and JWST observed 2024 YR4 on 26 March 2025. Analysis of the JWST data revealed the asteroid to be 60 ± 7 m in size, thereby markedly improving knowledge of this key asteroid property. Information from JWST about the position of 2024 YR4 in the sky also refined the asteroid's orbit.

In March, ESA's Hera spacecraft flew past Mars en route to rendezvous with the binary Didymos asteroid system and investigate the aftermath of NASA's Double Asteroid Redirection Test (DART) mission. The flyby went smoothly, and instruments on the spacecraft collected data of the Mars system, including its second moon Deimos, during the encounter. Critically, the mission successfully tested the natural feature tracking software onboard the spacecraft, which will enable autonomous navigation at Didymos.

Finally, the Purple Mountain Observatory in China is expanding its NEO observation network with new facilities, leading to the discovery of 70 new near-Earth asteroids and enabling routine monitoring and physical characterization of hundreds of NEOs annually.

Outlook

As part of the world's first test of asteroid deflection, ESA's Hera spacecraft will rendezvous with the asteroid 65803 Didymos in November 2026 to conduct over 6 months a detailed post-impact survey of the target Dimorphos (the orbiting moonlet of Didymous binary asteroid system). In September 2022, NASA's Double Asteroid Redirection Test (DART) successfully impacted Dimorphos at a high speed of ~6.6 km/s.

JAXA's Hayabusa2# spacecraft will perform a high-velocity flyby of asteroid 98943 Torifune in July of 2026, prior to its scheduled rendezvous with the small (~11 m diameter), fast-rotating asteroid (~5.35 minutes) 1998 KY26 in 2031. Hayabusa2# is extension of the Hayabusa2 mission that was launched in 2014, successfully rendezvoused with near-Earth asteroid 162173 Ryugu in June 2018 and returned samples to Earth in December 2020.

The Vera C. Rubin Observatory, formerly the Large Synoptic Survey Telescope (LSST), saw first light in June. This astronomical observatory, located in the Coquimbo Region of Chile, will scan the southern sky, capturing a new 3,200-megapixel image every 40 seconds. Every three nights, the telescope will revisit the same region of the sky, constructing a time lapse of the cosmos that will unfold over a decade. Rubin has multiple scientific objectives, but this "data deluge" is expected to increase the number of cataloged near-Earth objects by a factor of 10-100.

NASA's Near-Earth Object (NEO) Surveyor, a space-based infrared telescope with a 0.5 meter, is planned to launch in late 2027. NEO Surveyor will be the first space telescope specifically designed to detect asteroids and comets that may pose a potential hazard to Earth. Its primary objective is to meet the U.S. Congressional mandate to discover 90% of the estimated 25,000 potentially hazardous asteroids, objects larger than 140 meters that pass within approximately 20 lunar distances of Earth's orbit, within ten years. In addition to detection, NEO Surveyor will characterize these objects, provide data to support planetary defense missions, and lay the foundation for future survey efforts.

The year 2029 will be an exciting one for planetary defense. That year has been designated as the International Year of Asteroid Awareness and Planetary Defense by the United Nations, with the aim of promoting public awareness of asteroid impact hazards and the global coordination and communication measures that would be implemented in the event of a credible Earth-impact threat. That year's highlight will occur 13 April 2029, when asteroid 99942 Apophis will make an exceptionally close, but safe, approach to Earth, passing at a distance of approximately 32,000 kilometers above the surface. Apophis will be visible to the naked eye in some regions of the world. This close approach offers a unique scientific opportunity to characterize Apophis and to study the gravitational effects associated with an asteroid passing in such proximity to Earth.

Committee Activities

For 2025-2026, the IAF Technical on Planetary Defense

and Near-Earth Objects plans to launch several new initiatives. A Special Session proposal is being prepared for IAC 2026 in Antalya, Türkiye, with the goal of engaging students and early-career professionals through an interactive activity. Future initiatives are also expected to be coordinated with the Intrenational Astronautical Federation (IAF) Small Bodies Technical Committee to build sustained momentum toward the 2029 Apophis Earth's flyby and to establish a multi-year framework. The Committee also plans to undertake coordinated efforts in collaboration with SMPAG and with the International Year of Asteroid Awareness and Planetary Defense team. In parallel, the committee will continue to support community gatherings and technical exchanges among planetary defense experts, including those organized during the 2025 UK NEO Community Days, the Apophis T-X years workshops, the planetary defense sessions of various international congresses (EPSC, DPS, JpGU, AGU) and the Planetary Defense Conference 2027.

IAF Space CommunicationS and Navigation Committee (SCAN)

Introduction

The International Astronautical Federation (IAF) Space Communications and Navigation Committee (SCAN) deals with all aspects of space-based systems, services, applications, and technologies for communications and navigation. This includes fixed, broadcast, high-throughput, mobile, optical, quantum, and deep space communications, as well as position, velocity, time determination and tracking for navigation. The Internet of Things (IoT), Machine-to-Machine (M2M) topics, and Artificial Intelligence (AI) / Machine Learning (ML) technologies related to communications and navigation are also in the scope of this Committee.

Summary

The space navigation sector is evolving with new PNT services in LEO and lunar domains, while traditional GNSS systems advance with upgrades by India, Russia, China, the U.S., and Europe. LEO-PNT initiatives are expanding beyond Satellites/Iridium's STL, with demonstrations from Xona, ESA, and others. LEO-PNT developments must be viewed in the context of considerable interest in improving the resilience and reliability of GNSS-based navigation services due to the demonstrated vulnerability of GNSS-based navigation due to the alarming increase in jamming and spoofing of GNSS signals. Deep-space navigation faces capacity limits but sees progress with new DSN antennas and lunar GNSS experiments. Standardization efforts, such as LunaNet specifications and UN coordination, aim to enable interoperable lunar navigation services.
Space communications is developing rapidly due to its wide commercial and strategic applications. While wide beam and High Throughput Satellites (HTS) are still in-orbit, Medium Earth Orbit (MEO) satellites now provide backup capabilities that expand the applications. On other hand, private communication services in LEO are no longer limited by voice and low-speed data. Mega-constellations like Starlink, designed to provide high-speed internet to both enterprise and private use, are now capable of communicating directly with mobile devices. The new tendency is to build Very LEO (VLEO) mega-constellations to increase speed for mobile use and close gaps in terrestrial mobile networks by enabling direct-to-device connectivity. The map of users of mega-constellations has expanded. Intersatellite links, IoT and laser communication technologies are also being improved in order to expand multi-orbit communications systems, increase data speed and enhance automation for satellites and devices on the ground, on the ocean, and in the air.

Highlights

The space navigation sector is undergoing a transition, with new PNT services being introduced in both Lunar and LEO, alongside renewed calls for greater resilience and high accuracies in service delivery. With regard to traditional GNSS infrastructure upgrades, India is extending NavIC with an L1 civil signal using the new signal modulation format SBOC, Russia's GLONASS program is fielding it's K2-generation with its most recent launch in 2025, and China continues to increase its constellation size exceeding over 50 satellites across multi-layer orbits.

To support resilience, the U.S. continues GPS M-code roll-out with IIIF bringing Regional Military Protection (RMP) beam-steering when those spacecrafts are on-orbit, alongside a more rapidly deployed GPS constellation through the R-GPS program. Galileo's Open Service Navigation Message Authentication (OSNMA) moved from long-running test mode to initial service this year, providing civilian receivers with a free signal-authentication option against spoofing (data-level authentication on E1 I/NAV).
New LEO-PNT infrastructure makes advances, with new contenders from USA, China, Europe, Japan and the UAE, with other regions and nations also seeking to participate.

While Satelles/Iridium's STL remains the only operational LEO timing/positioning service at global scale today, Xona has demonstrated an in-orbit demo signal in the L1 and L5 bands. Other demonstrations have been proposed by Trustpoint, ESA, and ArkEdge Space, to develop signals in an extended band allocation towards VHF, S- and C-band, in addition to L-band.

Deep-space navigation infrastructure expands but remains capacity-constrained. NASA is adding DSN antennas (e.g., DSS-23) as loading pressures continue, while also ESA is bringing a new 35-m New Norcia dish online and upgrading sensitivity. LuGRE has however demonstrated the use of GNSS signals in the lunar domain, which would provide a pathway to alternative navigation systems alongside optical for lunar missions.

In January 2025, the LunaNet Interoperability Specification (Version 5) was released, providing a standard to how lunar communications & navigation providers could interoperate. This complements the signal-in-space draft ICD for a LunaNet signal, which are being developed by NASA, ESA and JAXA. India has proposed new pseudolite infrastructure for ground operations. UNOOSA's ICG has constituted a new working group WG-L dedicated to lunar PNT in an effort to coordinate various developments and to accelerate service delivery for lunar users.

A major highlight in the space communications field this year has been the rise of Direct-to-Device (D2D) and Direct-to-Cell (D2C) services. Last year, SpaceX launched Starlink satellites equipped for direct links to smartphones and successfully exchanged text messages using T-Mobile's network. Since then, it has begun offering direct communication services in collaboration with multiple telecom operators worldwide using Starlink satellites placed at an orbital altitude of 340 km, with data services expected to follow soon in addition to text messaging. Meanwhile, AST SpaceMobile launched five satellites under its BlueBird 1–5 mission in September 2024 and successfully deployed the antennas on all of them by October. In November of the same year, the company announced a next-generation plan to launch around 60 Block 2 BlueBird satellites and revealed multiple launch agreements with SpaceX, Blue Origin, and the Indian Space Research Organization (ISRO).

In terms of satellite constellations, Starlink has continued to increase its fleet, reaching 9,925 satellites launched by October 2025. In the United States, as of July 2025, the network was achieving a peak-time median downlink speed of up to 200 Mbps and a peak-time median latency of 25.7 ms. Expansion of the D2D satellites described above has been another key highlight. Amazon's Project Kuiper launched 153 satellites in October 2025 as part of building its planned 3,236-satellite constellation and is preparing to begin initial service by the end of the year. In China, China Satnet's Guowang and Shanghai Spacecom Satellite Technology's (SSST) Qianfan are emerging, each planning constellations of more than 10,000 satellites. Guowang launched its first satellites in December 2024 and Qianfan in August 2024, and both have now placed roughly 100 satellites into orbit. At the level of national and regional flagship programs, the European Commission (EC) and the European Space Agency (ESA) signed a contract in December 2024 with the SpaceRISE consortium, comprising SES, Eutelsat, and Hispasat, for the IRIS² program. The program plans to deploy a 290-satellite multi-orbit network in Medium Earth Orbit (MEO) and two layers of Low Earth Orbit (LEO) and aims to begin service by 2030.

Regarding optical satellite communications, in December 2024, the French Space Agency (CNES) and Airbus demonstrated successful tracking, downlink and uplink tests between TELEO geostationary in-orbit demonstrator and ground stations. The tests used several optical ground stations, including ESA's facility on Tenerife in Spain and, in France, both the FrOGS station at the Côte d'Azur Observatory and ONERA's FEELINGS, to demonstrate that laser links can reliably transfer large volumes of data between space and Earth under real conditions. The Space Development Agency (SDA) in the U.S. has successfully demonstrated inter-vendor optical link interoperability between York Space Systems and SpaceX Tranche 0 satellites. In September 2025, it was reported that a successful bidirectional optical communication test had been carried out between an SDA Tranche 0–compatible Kepler satellite and an aircraft. In the private sector, SES and Cailabs announced plans to demonstrate satellite-to-ground optical communications with next-generation optical ground stations. Aalyria, a Google spin-off operating in the U.S. and U.K., announced that its Tightbeam system maintained a 100 Gbps optical link across 65 km of atmosphere under real-world conditions. These and other players are pushing optical links into practical use.

High-Altitude Platform Stations (HAPS) flying in the stratosphere at around 20 km altitude, capable of providing low-latency communications, are also seeing accelerated activity in Japan, aimed at disaster recovery and coverage expansion in mountainous and remote islands. SoftBank has announced its intention to start pre-commercial HAPS services in Japan in 2026. It is also investing in Sceye, which develops lighter-than-air (LTA) HAPS, alongside its ongoing work on heavier-than-air (HTA) HAPS to speed up deployment. Meanwhile, Space Compass and NTT DOCOMO have invested in Airbus subsidiary AALTO, and successfully demonstrated smartphone direct 4G connectivity using its Zephyr platform at 20 km altitude over Kenya.

Outlook

As we look to the future, there will be a heightened focus on strengthening the resilience and accuracy of PNT. The incorporation of LEO satellite signals as "signals-of-opportunity" or the deployment of dedicated LEO navigation constellations shows promise of enhancing PNT capability in specific scenarios. This shift will require the development of new receivers and technologies

capable of managing the diverse signals from existing GNSS constellations and emerging LEO-based systems. Additionally, the distinction between military and civilian GNSS applications may lead to further advancements in the civilian sector to ensure secure and reliable PNT services.

Noteworthy progress is also being made in deep space navigation, particularly with the development of the Deep Space Atomic Clock (DSAC-2), which aims to offer unparalleled timing accuracy for interplanetary missions. The ongoing initiatives to establish a Coordinated Lunar Time system and advances in NASA's Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) highlight the increasing importance of precise navigation in cislunar space and beyond. As humanity prepares for more ambitious space exploration missions, these innovations will play a crucial role in enabling safe and efficient operations in increasingly challenging space environments.

The existing mega-constellations will continue to grow and upgrade, as more VLEO, LEO and MEO communication satellites will be launched. New capabilities provided by satellites may soon affect mobile devices standard functions, as in the case of GPS receivers introduced in the past. Cooperation between satellite and mobile network providers may grow as well. As satellite operators are entering multi-orbit business now, they may enter the mobile communications area in future.

Committee activities

The Committee approved updated session descriptions for IAC 2025 B2 symposium in Sydney and improved the abstract selection process by helping authors to properly identify the specific session for their submission. The International Astronautical Congress (IAC 2025) will be the second B2 symposium after the re-organization of each session and the Committee will monitor the situation and improve more for the next IAC.

The IAF SCAN Committee proposed the special session on "Building Bridges: Taking Optical Networks to Earth Orbit and Beyond" held at IAC 2025 in Sydney and sponsored by National Institute of Information and Communications Technology (NICT), Japan (Fig. 1). This interactive session brought the world of fiber-based communication technologies together with the space industry to explore how free-space optical communications is changing how we look at networks. The goal of this session was to explore technology roadmaps that could deliver the innovations needed to one day realize a truly interplanetary Internet.

Fig. 1. Special session on "Building Bridges: Taking Optical Networks to Earth Orbit and Beyond" organized by the IAF SCAN committee at IAC 2025 in Sydney and sponsored by NICT.

IAF Space Entrepreneurship and Investment Committee

Artemis and the Cislunar Economy: A Policy-to-Profit Framework for Entrepreneurship and New Markets.

Introduction

The International Astronautical Federation's (IAF) Space Entrepreneurship and Investment Committee (SEIC), established in 2007, operates as a vital global clearing-house, fostering economic innovation and attracting private capital to the space sector through dialogue, promoting the New Space Economy. The Committee actively directs this mission by coordinating the influential E6 Symposium on Business and Innovation at the annual International Astronautical Congress (IAC). Building on the foundational work of former Chairman Ken Davidian and Vice Chair Juergen Drescher, the SEIC, under the leadership of the current Chairwoman Nancy C. Wolfson (elected 2021) and Vice Chair Joerg Kreisel, is now a central catalyst for public-private partnerships. In 2025, the IAF Space Entrepreneurship and Investment Committee (SEIC) focused its attention on the NASA Artemis Program, which is profoundly influencing the New Space Economy by driving demand for lunar infrastructure and services,

effectively establishing the Moon as a new future economic zone. The Artemis Program could serve as a catalyst for entrepreneurial activity by providing anchor customer confidence through NASA contracts for lunar infrastructure and ISRU services, which de-risk novel space ventures and validate their business cases for private investment, allowing startups to scale their operations and attract further investment. By making the cislunar region economically viable, the Artemis Program lays the foundational requirement for private sector operations, thus driving demand for new space infrastructure companies specializing in everything from asteroid mining and in-orbit manufacturing to resource extraction hardware. Therefore, in a pivotal 2025 development, the IAF Space Entrepreneurship and Investment Committee (SEIC) partnered with the U.S. Office of Space Commerce (OSC) to host an exclusive Commercial Exploration Roundtable at IAC Sydney. This initiative highlighted that as lunar missions accelerate and private actors increasingly drive cislunar innovation, the relevance of public-private partnership (PPP) opportunities is surging, leading experts at the Roundtable to discuss PPP best practices, governance mechanisms, and sustainable cislunar commerce.

Summary

A significant area of commercial development is the launch industry, which experienced its highest operational tempo in the first half of 2025, recording 149 orbital launches by June 30. This intense activity is directly tied to the proliferation of satellite constellations, particularly in the competitive satellite broadband sector, where major players like SpaceX's Starlink are now facing substantial competition from emerging megaconstellations such as Amazon's Project Kuiper and Eutelsat's OneWeb. Investment trends simultaneously reflect a shifting and maturing market, with venture capital demonstrably continuing to secure funding. Market projections and experts suggest the economy could exceed $1 trillion by 2032, a growth trajectory driven primarily by advancements in communications and Earth observation satellites.

Highlights

The IAF Space Entrepreneurship and Investment Committee (SEIC) has been striving to advance its work across multiple aligned topics and relevant innovations occurring within the global space economy. The SEIC oversees the E6 Symposium, and in recent years, under the coordination of Nancy C. Wolfson, the Symposium's session topics have expanded. This evolution has allowed the committee to enter the global conversation, solidifying its status as a critical driver of dialogue that brings forth new trends in the New Space Economy and entrepreneurship, such as addressing how investments are increasingly focused on firms serving national security customers and those developing advanced communications and Earth observation capabilities, the latter playing a crucial role in enhancing predictive capabilities for disaster response. Technological advancements are rapidly opening new, non-traditional space markets, with In-orbit Servicing, Assembly, and Manufacturing (ISAM) emerging as a key growth area, supported by both government and private funding to develop capabilities like on-orbit satellite servicing and space debris remediation; for instance, startups like the UK-based Space Forge are pioneering the development of reusable orbital platforms designed for zero-gravity manufacturing of advanced materials. New entrants and startups continue to innovate in critical segments: Relativity Space is advancing the use of 3D-printed, reusable rockets like Terran R for medium-to-heavy lift, while other new companies like True Anomaly are focusing on autonomous orbital vehicles for space security and rendezvous operations. As we can see, the Space Economy is entering a new, dynamic era, the establishment of international professional platforms is not merely beneficial - it is absolutely paramount for driving consistent innovation through the strategic facilitation of Public-Private Partnerships (PPPs). Therefore, the International Astronautical Federation's Space Entrepreneurship and Investment Committee (SEIC), in partnership with the U.S. Office of Space Commerce (OSC), hosted a Commercial Exploration Roundtable at IAC 2025 in Sydney on Wednesday, 1 October. This exclusive, 36-seat session was co-organized by the IAF SEIC Chairwoman Nancy C. Wolfson and Rose Croshier from the U.S. Office of Space Commerce. This unprecedented meeting between the IAF SEIC and the US OSC brought together industry leaders and policy experts to address the challenges of accelerating lunar exploration, including risks of operational interference in confined regions and the need for coordinated best practices. The meeting agenda was guided by Mary Guenther, Head of Space Policy at the Progress Policy Institute, the discussion explored whether industry favors "soft" principles, binding rules, or new governance mechanisms to ensure safe, transparent, and sustainable cislunar activities with some specific aspects on the Artemis Accords. Designed as an initial but pivotal forum, the Roundtable seeks to bridge policy and practice, empowering the commercial sector to shape the standards that will define the future of space exploration.

Outlook

The outlook for the Space Economy is one of explosive growth and deep integration with the terrestrial economy. Beyond telecommunications, long-term trends point toward the rapid maturation of non-traditional markets and the foundational development of the cislunar economy (Earth to Moon). Space Resources, particularly the prospect of asteroid mining, are a critical, high-leverage component of this next era: the initial viability of this sector lies not in bringing precious metals back to Earth, but in extracting water ice from asteroids. Capitalizing on technological advancements in reusable launch vehicles, AI-driven data analytics, and miniaturization to transform space from an exclusively government domain into a collaborative environment for the development of new markets is a critical pillar of global economic infrastructure.

Committee Activities

The IAF Space Entrepreneurship and Investment Committee (SEIC) invites all IAF committees, participants, and associated stakeholders who are passionate about the intersection of technology, policy, and commercial space to join our efforts. The SEIC is spearheading a dynamic, project-based agenda focused on advancing the global New Space Economy. Our E6 Symposium on Business and Innovation will feature a brand-new E6.2 session in the making for the IAC 2026. Our dedicated Working Groups on Space Resources Utilization (including asteroid mining) and the New Space Economy & New Markets are actively seeking partners to co-author cutting-edge reports and help shape industry strategy. Our initiatives, which are under review and pending approval, such as the SEIC Pitch Day & Bootcamp for emerging technology ventures and our collaborative Annual Survey on emerging markets and future publications, are designed to generate high-impact research, foster strategic networking, and drive commercial innovation.

IAF Space Propulsion Committee

Introduction

The International Astronautical Federation (IAF) Space Propulsion Technical Committee addresses sub-orbital, Earth-to-orbit, and in-space propulsion. All types of propulsion are of interest to the committee: chemical rockets, electric propulsion, including conventional technologies such as Hall-effect, ion, pulsed plasma, electrodeless plasma, and electrospray thrusters as well as the advanced and newly emerged technologies such as the air-breathing propulsion and the propellantless technologies. The particular interest is given to nuclear and nuclear-powered propulsion as well as to the systems that are dedicated to the use aboard the small form-factor satellites. The symposium sessions organized by the Committee during the yearly International Astronautical Congress (IAC) include: liquid systems (2 sessions); solid and hybrid systems (2 sessions); electric propulsion (2 sessions); small satellite propulsion; nuclear propulsion and power systems; air-breathing rocket propulsion; disruptive propulsion systems enabling new missions. In the year 2025, the new session is added to the Space

Propulsion symposium that covers future trends in space propulsion.

The Committee deals with component technologies and testing facilities as well as complete propulsion systems, including their implementation in missions and satellites of different form-factors, discussions on in-orbit operations of propulsion systems of different types. Special attention is given to New Space developments, including miniaturized propulsion systems for small spacecraft/launchers and hybrid/multi-mode propulsion technologies.

Summary

In **North America**, SpaceX (USA) **Dragon** cargo spacecraft launched in August 2025 have not only delivered supplies and experiments to the International Space Station, but also will help the station maintain its orbit. Venus Aerospace (USA) conducted a successful flight test of a **rotating detonation rocket engine (RDRE)** integrated with an aerospike nozzle. While a first in-flight demonstration of such type of propulsion was done in 2022 in Japan by JAXA and Nagoya University using a solid rocket booster to launch the experimental platform, this flight used no other propulsion system, similarly as the late 2022 flight of Poland's Łukasiewicz Institute of Aviation detonative rocket engine. Venus Aerospace, unlike the previous in-flight demonstrations in Japan and Poland utilized a bi-propellant rocket engine using hydrogen peroxide as oxidizer. The test demonstrated sustained detonation combustion and effective adaptation to varying altitude conditions, laying the foundation for future high-efficiency propulsion systems and potential single-stage-to-orbit (SSTO) applications.

In **South America**, The Brazilian Space Program involves various public and private entities focused on developing launch vehicles and satellites. Efforts are centered on propulsion technologies, both chemical and electric, with significant contributions from DCTA, INPE, and UnB. Private firms are also advancing in solid, hybrid, and liquid propulsion. Notably, UnB recently created an additive manufacturing-based hybrid rocket engine, and the first commercial orbital launch from Brazil's Alcantara Launch Center is set to occur using a foreign company's hybrid-propulsion vehicle soon.

In **Europe**, in 2025, ARIANE 6 has confirmed the good results of its maiden flight of July 2024 with its 2 first successful commercial flights. The propulsion systems of the different stages worked nominally: the **P120C solid rocket motors** of the boosters, the **VULCAIN 2.1 LOX/LH2 engine** of the Lower Liquid Propulsion Module, the **VINCI LOX/LH2** engine and the **LOX/LH2 Auxiliary Power Unit (APU)** of the Upper Liquid Propulsion Module, giving Europe, together with VEGA-C, a return to full Space access capacity. The **P160 solid rocket motor** firing test, an upgrade of the P120C solid rocket motor that propels both Vega-C and Ariane 6 launchers, was tested in French Guyana 'Kourou' on 24 April 2025. The P160 motor firing test, close to 2 minutes, went well and according to initial recorded data, the performance met expectations. The P160C will allow Ariane 6 Block 2 and Vega-C to launch heavier payloads. The New Space is very active, with a lot of sub-system tests and engine tests all over Europe, e.g. in PLD Space, ISAR Aerospace, RFA, SIRIUS Space Services, LATITUDE, MAIA Space, HyPrSpace, Orbex, Pangea, The Exploration Company. In October 2024, POLARIS Spaceplanes (Germany) successfully achieved the first in-flight ignition of its **Linear Aerospike Engine (LAS)**. The vehicle, with a take-off mass of 229 kg and equipped with an integrated LAS, was ignited in flight and achieved an acceleration of 4 m/s^2 under rocket propulsion. The engine has accumulated 118 seconds of burn time operating with a LOX/kerosene propellant combination, and delivered a peak thrust of 943 N. In early 2025, Isar Aerospace (Germany) successfully completed integrated hot-fire testing of the first stage of its Spectrum rocket. The stage is powered by nine **Aquila engines** using liquid oxygen and propane. With over 120 hot-fire tests conducted, the campaign demonstrated mature, fully in-house propulsion architecture. The company MaiaSpace (France) conducted successful tests of several technologies for its Colibri kick-stage. This includes simultaneous firings of engines and reaching steady-state thermal conditions, using the **green propellant engine technology** under development at Łukasiewicz Institute of Aviation and supplied by Thaliana Space. The German Aerospace Center (DLR) continued its work on **rotating detonation combustion for RDRE applications** and successfully captured the first published visualization of rotating detonation combustion using oxygen and hydrogen in a small-scale **Rotating Detonation Combustor (RDC)** at the DLR in Lampoldshausen. Using a high-speed camera with a frame rate of 180,000 frames per second, the team obtained images of the detonation wave structure, allowing key wave characteristics such as fill height and shock angle. The fill height, or detonation wave height, was found to be around $9 \pm 2\ \lambda$, consistent with a well-known correlation by Bykovskii et al., but allowed the uncertainty for this configuration to be reduced. In the field of electric propulsion, The BepiColombo (joint ESA/JAXA mission to Mercury) equipped of four **QinetiQ-T6 Gridded ion thrusters**, has been able to cope with trajectory and propulsion adjustment over 2025. Coming back to LEO orbits, with more than 250 Field-emission electric propulsion (FEEP) thrusters in space in 2025, **ENPULSION** has become a global reference in electric propulsion for CubeSats and small satellites. The **ESA Electric Propulsion Lab** has accelerated its role of Enabler in 2025, increasing its support to various electric propulsion providers and ESA missions in the domain of small and green propulsion. Various tests have been conducted in 2025 with Hall effect (xenon, krypton, iodine), gridded ion, and water electrolysis propulsion thrusters. The ESA propulsion lab is now extending its capability to green chemical propulsion for R&D, supporting new companies and training with a **new ESA Chemical Propulsion Lab** to be inaugurated in February 2026 in **Netherlands Aerospace Centre.**

P160 solid rocket motor firing test at Kourou, French Guiana

POLARIS Spaceplanes' Linear Aerospike Engine (LAS) flight test firing

In **Asia**, Beijing-based start-up company Tianbing Technology - Space Pioneer (China) successfully completed a 30-second full scale static fire test of its **Tianlong-3 rocket's first stage propulsion** on 15 September 2025. The 72-meter-tall Tianlong-3 is a partially reusable, medium-lift vehicle capable of carrying 17 to 18 tons to low Earth orbit - comparable to SpaceX's Falcon 9. This test is a step forward to reusable rockets. It was conducted on a sea launch platform to enhance safety. This was a crucial step after a structural failure caused an unintentional launch during a static fire test in June 2024. Over 100 corrective measures were implemented since the June 2024 test, including strengthening the engine mounting section, adding new safety systems, and doubling the number of hold-down arms. The company is targeting the maiden launch of the Tianlong-3 for late 2025, possibly November or December. TiSPACE (Taiwan, China?) conducted a suborbital launch attempt of its **VP01 vehicle** from Hokkaido Spaceport in Japan on July 6. Although the rocket did not reach its target altitude of 100 km due to fin separation issues during ascent, the mission represented a significant step forward in international launch cooperation and highlighted TiSPACE's hybrid/solid propulsion capabilities. In Japan, the last flight of **H-IIA launch vehicle (No. 50)** took place in June 2025. JAXA has launched one H3 launch vehicle in 2025 so far. This version of the launcher is H3-22S, which features two LE-9 engines and two SRB-3 boosters. H3-24W, the new version of H3 rocket with two LE-9 engines and four **SRB-3 boosters**, will be launched in October 2025. Honda (Japan) has successfully conducted its first takeoff and landing test at an altitude of 300 meters using a prototype of its in-house reusable rocket. The test vehicle is a cluster-type rocket, powered by two engines **(LOX-Methane, 6.5kN thrust)** with a total height of 6.3 meters, a diameter of 85 centimeters.

Tianlong-3 rocket first stage propulsion test

In **Australia and Oceania,** in July 2025, Gilmour Space Technologies (Australia) performed the first test flight of the Eris orbital rocket from North Queensland with the engine firing duration of about 14 seconds.

Highlights

The International Astronautical Congress (IAC 2025) in Sydney (Australia) has been an unforgettable experience, having participants in the Propulsion symposium from all the continents, including presenters from many Oceania region countries. The main highlights of the Space Propulsion symposium of the IAC 2025 include:

- For **chemical propulsion**, University of Naples Federico II (Italy) has presented updates on experimental and numerical activities in support of the design of **CubeSat-scale hybrid rockets**, to be hosted on future ASI missions. Moreover, a novel test bench is being developed, for small-scale testing of gas-gas and gas-liquid bipropellants.
- For **electric propulsion**, SAFRAN (France) delivered an extensive review focusing on **Hall-effect thrusters with elevated specific impulses functioning under high voltages**. They emphasized that advancing these systems necessitates identifying innovative high-voltage resistant ceramic materials, developing methods to generate intense magnetic fields, and implementing improved thermal management strategies. Meanwhile, Magdrive (United Kingdom) shared updates regarding preparations for demonstrating the performance of their ***Rogue Pulsed Plasma Thruster*** in orbit.

Outlook

In the field of **electric propulsion**, the Advanced Propulsion Systems (Russia) successfully tested in space the capability of the **MTVEPT** thruster to control the

thrust vector direction by means of the magnetic field lines alterations aboard 6UXL-sized CubeSat HORS 3 launched from cosmodrome Vostochny on 5 November 2024. The angle in which the thruster vector direction is shown to be changed in space is 10 deg.

In the field of **micro-propulsion**, NeumannSpace (Australia) revealed the initial flight test results for the **center-triggered pulsed cathodic arc thruster.**

In the field of **space nuclear propulsion**, Space nuclear propulsion continues to advance as a strategic capability for deep space missions. The policy report "Weighing the Future: Strategic Options for U.S. Space Nuclear Leadership" (INL) published in July 2025 urges accelerated investment in nuclear power and propulsion systems to maintain U.S. leadership in cislunar and interplanetary space. On the technical front, the Centrifugal Nuclear Thermal Rocket (CNTR) concept proposes using centrifugal force to stabilize molten nuclear fuel, potentially overcoming key engineering challenges in NTP systems. The paper drew widespread attention, with coverage from outlets including Popular Mechanics, highlighting its potential to reshape crewed Mars mission architectures. In a major shift, DARPA canceled the DRACO program, citing declining return on investment. The joint DARPA-NASA initiative was deprioritized due to reduced launch costs from commercial providers like SpaceX, making NTP less cost-effective for cislunar operations. China and Russia have also reaffirmed plans for a lunar nuclear reactor. Chinese researchers also unveiled a 1.5 MW shrinkable fission reactor prototype, designed to deploy post-launch and propel spacecraft to destinations such as Mars, with initial ground tests successfully completed.

Committee Activities

The Committee is currently made of 49 members from 16 countries, including 9 female members and 12 young professionals, with good distribution among geographical areas and categories (industry, Academia, agencies). In 2025, several new regular Committee members have been welcomed in the Committee: Bhavyashree Janardhana (POLARIS Raumflugzeuge GmbH, Germany), Jamal Darfilal (Khalifa University, UAE), Jouke Hijlkema (ONERA, France).

The Committee is not only active in the organization of the International Astronautical Congress (IAC), but also fosters synergies with other relevant space propulsion conferences, such as the International Symposium on the Peaceful Use of Space Technology – Health (IPSPACE 2025) in December 2025 (Hainan, China), Joint 2nd Brazilian/Inter-American School and Workshop on Electric Space Propulsion in March-April 2026 (TBD) (Brasília, Brazil), Space Propulsion 2026 in May 2026 (Bari, Italy), 4S symposium in May 2026 (Sardinia, Italy), 27th AIAA International Space Planes and Hypersonic Systems and Technologies Conference in July 2026 (Naples, Italy). The Committee members are also active in knowledge dissemination to the space propulsion scientific community through the publication of papers and books.

IAF Space Security Committee

Introduction

Space security has become a defining issue in the international community, as the orbital environment grows more complex, contested, and congested. The increasing number and diversity of actors, together with the dual demands of protecting national interests and ensuring collective safety, underline the importance of building effective mechanisms for coordination and trust. Ensuring long-term sustainability, safety and security in space remains a shared responsibility by all nations.

Recent discussions have shown that questions of safety, security, sustainability, and stability cannot be addressed in isolation. Operational practices, technological developments, and strategic considerations are closely intertwined, and progress in one area depends on cooperation in another. The challenge lies in balancing transparency with legitimate security concerns, while at the same time advancing practical measures that reduce risks for all operators.

At the international level, both technical innovation and diplomatic dialogue are shaping the way forward. New approaches to data sharing, coordination, and operational safety are being developed in parallel with renewed efforts in multilateral forums to establish common ground and shared understandings. These complementary tracks highlight the need for engagement across government, industry and civil society, ensuring that solutions are both technically robust and politically viable.

Against this backdrop, the International Astronautical Federation (IAF) Space Security Committee continues to serve as a high-level forum where policy, strategy and technical expertise converge. By convening a broad community of stakeholders, the Committee fosters dialogue, strengthens mutual understanding and

contributes to shaping cooperative approaches that will be vital to safeguarding space for future generations. With its comprehensive scope and inclusive outlook, the Committee provides a unique meeting ground for addressing the challenges and opportunities of space security in all their dimensions.

Summary

In 2025, the IAF Space Security Committee convened in March, bringing together experts from government, academia, industry and civil society to exchange perspective on the year's most pressing space security issues and potential solutions.

During the meeting, **Marc Becker**, Policy Officer for Space Security at the German Federal Ministry of Defense, outlined the military perspective on Space Traffic Management (STM). He highlighted the growing recognition of space as an operational domain where military and civil activities coexist with commercial operations. His remarks underscored the need to integrate military requirements within STM frameworks, particularly in light of space congestion, debris and dual-use technologies, and issued a clear call for enhanced international cooperation among civil, commercial and military stakeholders to ensure safe and sustainable operations.

Additionally, **Guoyu Wang**, Dean of the Academy of Air, Space Policy and Law at the Beijing Institute of Technology, examined conceptional and political challenges facing the establishment of international mechanisms for Space Traffic Coordination and Space Security Governance. He stressed that safety (freedom from damage), and security (freedom from threat) are too often treated in isolation within different multilateral fora, whereas in reality, their scopes increasingly overlap, particularly in areas such as space debris mitigation, anti-satellite tests and in-orbit operations. He argued that space stability should serve as both the starting point and end goal of international space governance, recommending intensified diplomatic engagement on deterrence and security dynamics. He further noted that while legal norms should anchor multilateral dialogue, operational mechanisms may need to progress through bilateral channels, with mutual trust as a prerequisite for meaningful coordination.

We also had the opportunity to listen to **Mariel Borowitz**, Head of International SSA Engagement in the US Office of Space Commerce, who provided an update on the Traffic Coordination System for Space (TraCSS). She explained that TraCSS represents a significant institutional shift in the United States, transferring responsibility for civil spaceflight safety services from defence to a civilian authority. Built to ingest data from government, commercial and international sources, TraCSS aims to deliver accurate, timely and accessible services to satellite operators worldwide. Its open-data policy was highlighted as an important step towards transparency and operator-to-operator coordination across borders, positioning the system as a model for how national initiatives can contribute to broader international efforts in spaceflight safety.

Finally, **Sarah Erickson**, Project Coordinator at the UNIDIR Space Security Programme, briefed the Committee on the status and evolution of the OEWG on PAROS. She recalled that, while earlier processes faced challenges, the conclusion of the second GGE with a consensus report in 2024 marked an important milestone. Building on this momentum, the decision was taken to merge two parallel OEWGs – one on norms, rules, and responsible behaviours, the other on substantive legal elements toward a treaty – into a single OEWG on PAROS. Looking ahead, the OEWG is expected to focus on the intentional destruction of space objects, the deployment of space systems for hostile purposes, interference with space object operations, military doctrines and policies and the challenge of developing shared definitions and understandings of space threats and responsible behaviour.

At the March meeting, we also welcomed two new members: **Rachel Venn**, from the Space Generation Advisory Council, and Rong Chen, Senior Engineer at the China Academy of Launch Vehicle Technology. Their appointment reflects the Committee's broadening expertise and its commitment to fostering the engagement of young professionals in the space security dialogue.

Highlights

In 2025, the Space Security Committee observed important advancements shaping the future of space safety, security and sustainability. New initiatives such as TraCSS underscored the growing importance of civilian-led, open-data approaches to spaceflight safety, while the continued growth of international SSA systems promises improved accuracy and accessibility for operators worldwide.

Equally significant were steps forward in international governance, with the consolidation of processes under the new OEWG on PAROS. This unified forum brings together normative and legal discussions, strengthening multilateral dialogue on space threats, responsible behaviours, and long-term stability.

Together, these developments underscore a clear trend: collaboration is becoming a cornerstone of space security. By combining technological innovation with renewed multilateral engagement, the international community is laying the groundwork for a safer, more secure, and more sustainable space environment for the future.

Outlook

In the coming years, the Committee will continue to prioritise global cooperation in space security, closely

monitoring the progress of multilateral initiatives such as the OEWG. A central focus will be on promoting a holistic approach that recognises the interdependence of space safety, security, sustainability and stability. Key areas of discussion are expected to include the evolution of STM practices, the strengthening of space awareness capabilities, and the development of governance frameworks that balance transparency with national security considerations.

The Committee will also remain a forum of high-level dialogue, inviting distinguished speakers across government, industry, academia, and civil society to share their perspectives and expertise. By fostering inclusive exchanges and forward-looking debates, the Committee aims to support the international community in shaping cooperative solutions that safeguard space for future generations.

Committee Activities

The Committee will continue encourage members' engagement on both policy and technical matters of common concern, maintaining close links with other IAF Committees and sub-committees of relevance. Participation from emerging spacefaring nations will remain a priority, recognising the increasingly global character of space as a critical infrastructure.

At future meetings, the Committee will focus on challenges in space traffic coordination and on the integration of commercial actors into space security frameworks. Special attention will be given to improving alignment between existing and developing SSA systems across different regions, with the aim of enhancing coordination and supporting global safety and sustainability. At the same time, the Committee will closely follow the official, multilateral processes where space security remains a key focus of international dialogue. By combining technical insight with strategic foresight, the Committee will reinforce its role as a leading voice in advancing cooperative approaches to space security.

IAF Space Systems Technical Committee

Introduction

The International Astronautical Federation (IAF) Space Systems Committee addresses the broad field of space systems, with a focus on system concept design and systems engineering perspectives. Core aims of the Committee include the continual enhancement of system development and reliability, the consolidation and dissemination of lessons learned, and the drive to improve cross-disciplinary efficiency and risk management. As the global space ecosystem transforms through technological innovation and new architectures, the Committee also emphasizes visionary concepts, sustainable practices, and future-oriented business and mission models.

Summary

This year has been marked by accelerating convergence between digitalization, autonomy, and system-level sustainability within the space sector. At International Astronautical Congress (IAC 2025), the IAF Space Systems Symposium revealed several major developments in these areas:

- Distributed architectures and autonomy are now mainstream research directions rather than niche explorations. The maturation of AI and on-board data processing, combined with rapid advances in miniaturization, additive manufacturing, and edge computing, is enabling smaller systems to perform complex, coordinated tasks historically reserved for flagship missions.
- Equally important is the growing recognition of sustainability as a system-level design driver. Space systems are increasingly designed with life-cycle awareness (reusability, recyclability, and end-of-life operations are being considered at the earliest stages of system conception). This year's programme revealed a marked shift toward circular economy principles in orbit: reconfigurable platforms, in-orbit manufacturing, and closed-loop logistics chains are redefining the boundaries of space engineering.
- At the engineering level, Model-Based Systems Engineering (MBSE) and Digital Twin approaches are converging into what might be termed "live systems engineering", a continuous process of design, simulation, and operational validation. The integration of AI into these workflows allows systems to evolve dynamically in response to mission changes, environmental challenges, or hardware degradation.

Overall, 2025 has been a transformative year for space systems, signalling the emergence of a new systems approach defined by artificial intelligence, operational adaptability, and sustainable design philosophy.

The IAF Space Systems Symposium at IAC 2025 covered these topics in the following sessions:

- Innovative Systems toward Future Architectures
- Technologies that Enable Space Systems
- Emergent Space Systems
- Cooperative Systems
- Systems Engineering Modelling and Analysis
- Systems Engineering Approaches, Processes and Methods
- Lessons Learned in Space Systems

Highlights

The following trends and breakthroughs were identified in the IAF Space Systems Symposium at IAC 2025 in what concern future architectures and innovative systems:

- *Sustainable Architectures:* Space-based solar power and orbiting reflectors became credible solutions for Earth energy needs; eco-design principles and reduced resource footprints became a driver for new system concepts.
- *Cooperative and Distributed Systems:* Formation flying systems and self-organizing distributed satellite constellations were emphasized as enablers for managing complex space operations.
- *In-Orbit Services:* Demonstrations and commercial deployments showed promising results in both ADR and ISAM, with reusable platforms and on-orbit recycling supporting a circular economy in space.
- *Very Low Earth Orbit (VLEO) Missions:* Multiple VLEO demonstrations addressed challenges in atmospheric drag and mission longevity, fostering new application domains for Earth observation and rapid revisit.
- *Human-Centred Design:* Advances in Human System Integration (HSI), usability, user-centric interfaces (AR/VR), and modular, scalable satellite systems improved operational adaptability and crew safety, especially for lunar, Martian, and orbital habitats.
- *AI and Machine Learning:* On-board intelligence (such as cognitive SAR, adaptive imaging, and autonomous mission planning) became central to managing large-scale data and operations, reducing ground overhead and accelerating feedback cycles.
- *Digital Transformation in Systems Engineering:* The ongoing integration of Model-Based Systems Engineering (MBSE) with Artificial Intelligence, Machine Learning, and Digital Twins was underlined for boosting design efficiency, risk management, and lifecycle optimization despite implementation challenges.

Outlook

The coming years will see space systems evolve into more intelligent, autonomous operating, resilient, and interconnected networks.

Artificial intelligence and autonomy will become deeply embedded in spacecraft design and operations, enabling missions to rely more heavily on onboard decision-making capabilities for optimizing trajectories, managing resources, and adapting autonomously. This integration of AI for autonomy will necessitate the development of new verification and validation methodologies to guarantee the safety, reliability, and robustness of systems that continuously learn and evolve during their mission lifetimes. At the same time the integration of AI in digital engineering tools (MBSE and Digital Twin) will transform the entire system lifecycle by enabling real-time simulation and predictions in all mission phases.

Sustainability will increasingly become a key system design driver as the industry responds to orbital congestion and environmental concerns. Future systems will be conceived with end-to-end life-cycle responsibility, incorporating modular designs for in-orbit servicing, repair, and recycling. In parallel, the growth of in-space logistics and manufacturing will open new opportunities for reusable infrastructure and long-duration missions.

Several exciting projects on the horizon reflect this transformation. New-generation constellations will test co-operative autonomy and resource sharing. On-orbit servicing demonstrators will validate repair and refuelling capabilities. VLEO missions will open new opportunities for rapid revisit Earth observation and communication services. Lunar and cislunar systems will serve as testbeds for distributed operations and resilient architectures. Collectively, these developments point toward a future where space systems are not static assets but adaptive, evolving components of a sustainable and intelligent space ecosystem.

Committee Activities

The IAF Space Systems Technical Committee is currently made of 30 members, including young professionals, and with good distribution among geographical areas (representing 12 countries) and categories (industry, academia and agencies).

The committee is chaired by Matteo Emanuelli (Airbus Defence & Space). Jill Prince (NASA) and Mamatha Maheshwarappa (UK Space Agency) act as Vice-Chairs.

For 2026, the Committee is preparing to participate in the IAF Technical Webinar Series, to share technical insights on current space system innovations and emerging trends in the field.

Figure 1IAF Space Systems Committee at IAC 2025

IAF Space Transportation Committee

Introduction

The objective of the Space Transportation Committee (STC) of the International Astronautical Federation (IAF) is to address worldwide space transportation solutions and innovations. In particular the goals are:

- To foster understanding and cooperation amongst space business academicians and practitioners, through the creation, diffusion, and adoption of new knowledge (i.e., research exploration, from academics to practitioners) and lessons learned (i.e., experience exploitation, from practitioners to academics)
- To build a worldwide network of communication and relationships between space business amateurs and professionals, by providing a forum of discussion, disclosure, creative thinking (i.e. brainstorming), and information sharing.
- To encourage, promote, and assist the development of newer members of the space community through International Astronautical Congress (IAC) participation. The corresponding activities are devoted to different types of space transportation missions, systems (launch vehicle system and/or the propulsion stages, expendable or reusable, manned or unmanned) and to their safety and support operations.

The activities of the IAF STC include the following:

- Proposal and organization of IAC symposium and sessions, including identification of relevant space-related topics to be included in the Call for Papers.
- Participation in the paper selection as International Programme Committee (IPC) Members.
- Participation as IPC Members (Chairs, Rapporteurs and Symposium Coordinators) - Organization of dedicated conferences, publications.
- Participation in the IAF Committee Briefs and the annual IAF Highlights.

Summary

The major development in the space transportation field is the increase in size of launch vehicles like Starship, New Glenn, Arian 6 and Long March 10 that allow new missions in Low Earth Orbit, but also to the Moon and to the Mars. Another major trend is the consideration of re-usability of launch vehicles.

Highlights

Ariane 6 status

After the very successful inaugural flight of Ariane 6 on 9 July 2024 and the correction of lessons learned on the Auxiliary Propulsion Unit, the two subsequent commercial flights went very smoothly. Both SSO flights, on 6 March 2025, and 12 August 2025 delivered their payloads with high precision, matched exactly the flight predictions and led to upper stage deorbitation after several upper stage re-ignitions.

VEGA and Space Rider

The VEGA-C rocket, which returned to flight in December 2024 flew twice successfully on 29 April and 26 July 2025 and is preparing a third flight in November 2025. The development of VEGA-E featuring a new cryogenic Methalox upper stage is under development and the preparations for a first Space Rider flight are continuing.

Building blocks and demonstrators to shape the future

Preparing Europe for reusability, the Prometheus engine testing continues, and such engine will power the Themis vehicle, a first stage reusability demonstrator set for low altitude take-off and landing demo flights in Kiruna, Sweden in the coming weeks.

European Launcher Challenge and micro launcher segment

Both under EU/ESA initiatives as the European Launcher Challenge, as well as on own funding initiatives, several European companies are gearing up to enter the launcher market in the near future. First flight attempts by PLD Space (successful, October 2023 with Miura 1 and preparing now the debut of Miura 5) and ISAR Aerospace (successful liftoff of Spectrum, 30 March 2025) have taken place and will soon be joined by companies such as Rocket Factory Augsburg, MaiaSpace, Orbex, Latitude and others.

SpaceX

SpaceX continues to conduct rapid and reliable operations in 2025 including 168 Falcon launches and 7 completed Dragon operations. For the first time, SpaceX has also launched and landed a Falcon booster 30 times. Starship development advanced over the past year, with some setbacks but also notable technical progress. In-flight experiments on booster flyback and ship re-entry provided valuable data, contributing to the continued expansion and validation of Starship's flight envelope. The Starlink constellation continues to grow with over

8,000 satellites on orbit servicing over six million customers worldwide.

Fig. 1 Starship Flight 10 Liftoff

Tianwen - 2

On 29 May 2025, China launched its first Asteroid Sample Return probe, Tianwen-2, by Long March -3B launch vehicle. The probe is composed of an orbiter and a returner. It will take one year to reach Asteroid 2016HO3, get the sample and bring it back to Earth with its returner. Then the orbiter will fly towards 311P, a comet in Main Asteroid Belt. The whole mission will take about 10 years.

New development on China's Manned Lunar Program

China plans to send astronauts to Lunar surface before 2030. To achieve this goal, China Manned Space Agency conducted several important experiments in recent months. For Mengzhou manned spaceship, which will bring three astronauts to Lunar orbit and back to the Earth, tested its emergency escape system on 17 June 2025. For Long March-10 launch vehicle, with LTO capability of 27 tons, conducted static fire test on its launch pad twice on 15 August and 13September respectively. For Lanyue, its manned lunar lander, conducted integrated landing and ascending test on 7 August.

H-IIA, H3

On 29 June, MHI successfully launched the 50th and final H-IIA, retiring a vehicle that had provided access to space since 2001. By February 2025, five H3 had launched, and in July 2025, H3-30, simplest configuration completed a captive firing test. On October 2025, the most powerful configuration H3-24 is scheduled to launch the first HTV-X cargo spacecraft to the ISS. HTV-X, developed by JAXA, MHI, and MELCO, succeeds the HTV. In 2024, JAXA and MHI initiated planning for the H3 enhanced program, comprising projects to expand satellite launch diversity, enable higher launch frequency, and enhance launch capability, with development to begin in 2025.

Brail's launch vehicle

As Brazil approaches its first commercial orbital launch from the Alcantara Launch Center, the country looks forward to new opportunities in access to space. With a new legal and regulatory framework that supports space activities, allied with the recent creation of a state-owned enterprise, Alada, responsible for the commercialization of such activities, Brazil intends to attract launch companies from different nationalities and to grow the national and regional space ecosystem. As this restructuring progresses, the Brazilian Space Agency will act as the civil authority in space transportation matters. Meanwhile, national efforts for the development of launch vehicles and suborbital rockets have expanded into the private sector, creating a vibrant community between public and private actors, as well as innovative solutions for ongoing and future projects.

Outlook

With two more flights scheduled for end of 2025, Ariane 6 is projected to see the fastest ramp up in its peer group (5 flights in 17 months, followed by 8 launches in 2026).

In parallel, the preparation of upgrades to Ariane 6 Block 2 configuration is ongoing. The upgraded boosters will be available by the end of 2025 and full Block2 performance (21.9t in LEO), is expected in the end of 2026.

Significant further launch service upgrades under development include the Multi Launch Service configuration and the ASTRIS vehicle, compatible with Ariane 6, which is a Moon capable in orbit transfer vehicle. In 2025 and 2026, two private companies of China will conduct first flight tests of their reusable launch vehicles. The methane based Zhuque-3 has a LEO capability of 21.3 tons in expendable mode and 18.3 tons in reusable mode, with 4.5m diameter of its first and second stage. The kerosene based Tianlong-3 has a LEO capability of 17 tons, with 3.8m diameter of its first and second stage.

SpaceX will continue its flight test on Starship and construction of Starlink constellation.

Committee Activities

The Committee is currently made of more than 70 members from all over the world including South America, Australia, North America, Europe and Asia. During the IAF Spring Meetings in March 2025, Geovian Tadzi Stower of Kenya Space Agency became the first Committee Member from Africa. Ysolde Prevereaud from ONERA became another female member of the Committee. A good distribution is given with a high number of female members and young professionals + students, and also a good distribution among categories (industry, academia, agencies).

During IAC 2025 in Sydney, the Committee successfully organized D2.1~D2.9 Sessions and IP Sessions of D2 Symposium. On October 2nd, Committee Members joined the traditional IAF STC Dinner in Sydney.

Fig. 2 Group photo of Committee Members during the IAF Spring Meetings 2025

Fig 3. Geovian Tadzi Stower and Ysolde Prevereaud joined IAF STC during the IAF Spring Meeting

In April 2025, Prof. Dr. Yang Yuguang, Chairman of Space Transportation Committee was invited to join the CGTN (China Global Television Network) live coverage of the launch of Shenzhou-20 manned spaceship and return of Shenzhou-19 manned spaceship. He introduced the technical features of China's Crew transportation system and important experiments accomplished onboard China's Tiangong Space Station.

Fig 4. Prof. Dr. YANG Yugang, chairman of IAF STC on live coverage of Shenzhu-20 spaceship launch

The IAF Technical Committees Webinar Series in cooperation with the IAF Workforce Development/Young Professionals Programme (WD/YPP) Committee

The International Astronautical Federation is the world's largest hub of space enthusiasts, many of them participating in the IAF Technical Committees.

Composed of experts and global leaders who discuss and lead the evolution of space activities, these are powerful source of knowledge that shape the discussion of the yearly IAF events.

In this frame, the IAF Workforce Development/Young Professionals Programme (WD/YPP) Committee launched a new initiative aimed at recognizing the pivotal role of the Next Generation in the space sector as well as disseminating technical content through the IAF media platforms: The IAF Technical Committees Webinar Series.

Following presentation during the annual IAF Spring Meetings, the IAF WD/YPP Committee held in 2025 three webinars focusing on relevant aspects of the new space era in cooperation with the IAF Space Propulsion Committee, the IAF Space Economy Committee and the IAF Earth Observation Committee.

Streamed on the IAF official YouTube channel, the events witnessed a large success among the community, with lively sessions moderated by the Vice-Chairs of the IAF WD/YPP Committee, where speakers had the opportunity to share their knowledge and visions on the most trending topics of their fields of expertise. Each session was followed by live Q&A sessions, allowing the audience for a direct engagement with the panellists.

The format turned out to be a successful hub where space and non-space community worldwide can get acquainted with latest trends and developments in the space sector.

The activity will resume in 2026 with the coverage of other key areas of the space industry, in cooperation with the other IAF Technical Committees.

The IAF Logbook 2025

IAF Logbook 2025:

Mapping a Year of Global Space Collaboration

The International Astronautical Federation (IAF) continues to advance its mission of "Connecting @ll Space People" by representing the collective voice of the global space community and promoting collaboration across all space sectors.

Beyond organizing the world's largest and most prestigious gatherings – the International Astronautical Congress (IAC) and the IAF Global Conferences – the Federation plays a pivotal role on the international stage, engaging with space leaders from government, industry, academia, and civil society. Through its multidisciplinary expertise, the IAF contributes meaningfully to strengthening dialogue and advancing global cooperation in space.

Launched in 2024, the IAF Logbook stands as a chronicle of the Federation's expanding presence and influence worldwide. Inspired by the captains' logbooks that once charted great voyages, this initiative captures the IAF's participation in high-level conferences and strategic forums, illuminating its enduring efforts in space advocacy outreach.

The IAF Logbook 2025 captures a year rich in international activity - with **20 events held across 12 countries on 4 continents**, reflecting the truly worldwide reach of the IAF's mission to advance space advocacy and cooperation.

Through the **IAF Logbook**, you can explore how the Federation continues to strengthen its presence on the international stage, contributing to key global discussions and initiatives that shape the future of space. From Vienna to Hefei, and from Colorado Springs to Rabat-Salé, the IAF has remained an active voice promoting international collaboration.

We welcome you to explore the **IAF Logbook 2025** - a journey through the Federation's activities that continue to unite the world through space!


IAF LOGBOOK 2025
WINTER
SPRING
SUMMER
AUTUMN
2025
17th European Space Conference
AMESC
AFRICA & MIDDLE EAST SPACE CONFERENCE
UNITED NATIONS
Committee on the Peaceful Uses of Outer Space
AACII
40TH SPACE SYMPOSIUM
SPACE FOUNDATION
NEWSPACE
AFRICA CONFERENCE
中国航天大会
International Conference on Space for Climate Change
AFRICA SPACE ECONOMY
CONFERENCE & EXHIBITION
供应商合作发展座谈会
LIVING PLANET SYMPOSIUM
UNITED NATIONS
Committee on the Peaceful Uses of Outer Space
ASCEND
G20 SOUTH AFRICA 2025
3rd International Deep Space Exploration Conference (Tiandu Forum)
6th SciTech Forum on Space Engineering and Operations Support

20TH ILAN RAMON INTERNATIONAL SPACE CONFERENCE

27 January 2025
Tel-Aviv, Israel

The 20th Ilan Ramon International Space Conference took place in Tel-Aviv, Israel, on 27 January 2025 under the theme *"Standing Together. Building The Future"* as part of Israel's annual Space Week.

IAF Executive Director Christian Feichtinger participated in the panel titled *"Innovation, Collaboration, and Challenges in National Space Programs: A Global Perspective on Space Development"*. Alongside distinguished speakers as Uri Oron, Head of Israel Space Agency (ISA) and Teodoro Valente, President of Italian Space Agency (ASI), Christian Feichtinger highlighted the IAF's role in fostering international cooperation and innovation globally.

He emphasized the importance of platforms like the International Astronautical Congress (IAC), the IAF Global Networking Forum (IAF GNF), the IAF Global Space Leaders Summit and the IAF Emerging Space Leaders (ESL) Grant Programme in promoting dialogue, inclusivity, and knowledge-sharing between established and emerging space nations.

IAF Executive Director also addressed pressing global challenges, including space sustainability. He reinforced the IAF's commitment to supporting Israel's growing space capabilities through collaborative initiatives with the Israel Space Agency. These efforts aim to advance emerging technologies, promote equitable access to space, and ensure the inclusion of new space nations in the global space community.

17TH EUROPEAN SPACE CONFERENCE

28 - 29 January 2025
Brussels, Belgium

Strengthening global space dialogue, the IAF participated in the 17th European Space Conference on 28 - 29 January 2025, in Brussels, Belgium.

As part of the conference, the IAF hosted its traditional VIP Luncheon, bringing together top space leaders and policymakers. IAF President Clay Mowry and IAF Executive Director Christian Feichtinger welcomed distinguished guests, and Ekaterina Zaharieva, European Commissioner for Startups, Research, and Innovation, and Josef Aschbacher, Director General of the European Space Agency (ESA) addressed the guests with welcome remarks on space policy, international cooperation, and Europe's role in the global space sector. Teodoro Valente received the certificate as appreciation of his invaluable contribution to the Inaugural IAF Global Space Leaders Summit.

On 29 January, Christian Feichtinger joined the panel *"International Cooperation: An Exchange of Views"* and shared the stage with Eric Morel de Westgaver, Director of Strategy, Legal and External Affairs of ESA, Tidiane Ouattara, President of the African Space Council of the African Space Agency, Raúl Kulichevsky, Executive and Technical Director of National Commission for Space Activities in Argentina (CONAE), Marjolijn van Deelen, Special Envoy for Space of European External Action Service (EEAS), and Hermann Ludwig Moeller, Director of European Space Policy Institute (ESPI).

During the discussion, Christian Feichtinger emphasized that international space relations are not only about cooperation but also about competition, which can drive technological innovation and strategic advancements. He highlighted the importance of balancing these dynamics to ensure sustainable growth and equitable access to space.

AMESC
AFRICA & MIDDLE EAST SPACE CONFERENCE

AFRICA AND MIDDLE EAST SPACE CONFERENCE (AMESC) 2025

5 - 8 February 2025
Rabat-Salé, Morocco

The International Astronautical Federation (IAF) reaffirmed its commitment to fostering global collaboration in the space sector through its participation in the Africa Middle East Space Conference (AMESC) 2025. Organized by the Moroccan Initiative for Space Industry (MISI) and hosted by Mohammed VI Polytechnic University (UM6P), AMESC served as a needed opportunity for space stakeholders from the region and beyond to exchange insights, strengthen cooperation, and advance joint initiatives under the Conference motto *"Charting New Horizons in Africa and the Middle-East"*.

As part of AMESC 2025, the IAF Administrative Committee on Connecting Emerging Space ecoSystems (IAF ACCESS) organized a High-Level Workshop on *"Space for Global Challenges"*. Moderated by Charles-Aimé Nzeussi-Mbouendeu and Imane El Khantouti, respectively Chair and Vice Chair of IAF ACCESS Africa Subcommittee, and the workshop proved to be both productive and engaging.

The workshop focused on how space technologies and innovations can address global challenges, ranging from climate change to sustainable development. The event highlighted Africa's rapid progress in space projects, showcasing the continent's growing contributions to space.

The discussions identified several potential areas for development and capacity building, emphasizing the exciting opportunities ahead. The workshop laid a strong foundation for further collaborations and partnerships, reflecting Africa's increasing role in the global space ecosystem.

62ND SESSION OF UNOOSA SCIENTIFIC AND TECHNICAL SUBCOMMITTEE

10 - 11 February 2025
Vienna, Austria

The 62nd Session of the Scientific and Technical Subcommittee (STSC) of the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) took place in Vienna, Austria, from 3 to 14 February 2025. The annual meeting brought together more than 100 country delegations and more than two dozen observers to discuss and contribute their perspectives on issues related to the civil and peaceful uses of outer space, including orbital debris, long-term sustainability, and use of space for global health and sustainable socio-economic development.

IAF once again participated in its role as a permanent observer to the Committee. IAF Vice President on Relations with International Organizations Anil Kumar made a statement under the Exchange of Views agenda item that provided an update on IAF activities and upcoming events, including the IAF Global Space Exploration Conference (GLEX 2025) in New Delhi, India and the 76th International Astronautical Congress (IAC 2025) in Sydney, Australia.

One of the highlights of the 62nd Session of STSC was the IAF Symposium, a biennial event organized by the IAF on 11 February 2025. The Federation extended its gratitude and respect to the United Nations Office for Outer Space Affairs (UNOOSA) and to its Director - Aarti Holla-Maini for her leadership and outstanding cooperation with the IAF. The 2025 edition of the IAF Symposium explored the theme: *"Space – Indispensable on the Agenda of Policymakers, Public, and Nations"*.

2ND AVIATION AEROSPACE INTERNATIONAL INTERDISCIPLINARY CONGRESS (AACII 2025)

12 February 2025
Nuremberg, Germany

The 2nd Aviation Aerospace International Interdisciplinary Congress (AACII) brought together professionals and researchers from the aerospace and aviation sectors to discuss advancements, challenges, and the future trajectory of the industry.

As part of congress Pascale Ehrenfreund, former President of the International Astronautical Federation (IAF) and current President of the Committee on Space Research (COSPAR) moderated the SpaceForum Roundtable Discussion. The panel featured esteemed experts, including Christian Feichtinger, Executive Director of the IAF.

The discussion focused on the transformative impact of the New Space Economy. The panel members highlighted how the

increasing participation of commercial space actors, alongside new and emerging space counties, is leading to paradigm shifts and disruptions within the space sector. This evolution is fostering innovation, reducing costs, and expanding access to space technologies and services globally.

THE 39TH SPACE SYMPOSIUM

7 - 10 April 2025
Colorado Springs, United States

The 40th Space Symposium, one of the largest international events dedicated to all sectors of space, organized by the Space Foundation, took place in Colorado Springs, United States from 7 to 10 April 2025 under the theme *"Building Partnerships to Secure Our Future"*.

The Symposium kicked off with the Space Generation Fusion Forum (SGFF), where the IAF Executive Director Christian Feichtinger addressed students and young professionals. His speech empowered the next generation of space leaders and further strengthened IAF's ongoing collaboration with the Space Generation Advisory Council (SGAC).

The second day was highlighted by a Salon Breakfast, organized by the IAF, titled *"Connecting @ll Space People for a Sustainable Future"*. Moderated by Christian Feichtinger, the event featured prominent speakers such as Josef Aschbacher (European Space Agency), Steve Eisenhart (Space Foundation), Clay Mowry (IAF), and Enrico Palermo (Australian Space Agency). This informal gathering offered an opportunity for colleagues to connect, share ideas, and share a warm invitation to attend the 76th International Astronautical Congress (IAC 2025) in Sydney, Australia, from 29 September to 3 October 2025.

NEWSPACE AFRICA CONFERENCE 2025

21 - 24 April 2025
Cairo, Egypt

The inauguration of the African Space Agency (AfSA) paved the way for the NewSpace Africa Conference which took place on 21-24 April in Cairo, Egypt. The conference embraced the theme *"Empowering Africa's Economy through Space-driven Innovation"* and brought together industry leaders to discuss the growth & future of the African space industry.

IAF Executive Director Christian Feichtinger delivered a keynote presentation *"Empowering Africa's Presence in the International Space Arena"*, showcasing the Federation's inclusive global mission and its strong support for the African space community.

With 19 active members from across the African continent, IAF emphasized its commitment to fostering sustainable development, capacity building, and high-level dialogue through initiatives like the IAF Global Space Leaders Summit and the IAF Africa Subcommittee under the IAF-ACCESS (Committee on Connecting Emerging Space ecoSystems) framework.

A key highlight of the presentation was the IAF's Emerging Space Leaders (ESL) Programme, which has supported 47 young African professionals since 2009 and continues to grow. The Federation also spotlighted Africa's increasing contributions to International Astronautical Congress (IAC), with a record 200 abstract submissions from 16 African countries for IAC 2025 in Sydney.

INTERNATIONAL CONFERENCE ON SPACE FOR CLIMATE CHANGE

24 - 26 April 2025
Shanghai, China

This year marks the 10th anniversary of China Space Day. More than 40 activities were held across the city of Shanghai, ranging from conferences and forums to exhibitions and technical exchanges.

The International Astronautical Federation (IAF) was pleased to extend its warm congratulations to the China National Space Administration (CNSA) and to the esteemed IAF Members from China on this important occasion and the successful launch of the Shenzhou-20 manned space mission.

The TV programme *"Space for All"* on China Global Television Network (CGTN) featuring the interview with IAF Executive Director was dedicated to the recent developments of Chinese Space Sector.

On 25 April, the IAF participated in the International Conference on Space for Climate Change, contributing with the presentation under the theme *"Expanding Global Space Partnerships to Address Climate Change"*. Christian Feichtinger outlined the IAF Bureau's key priorities for the period 2022-2025, namely Sustainability, Investment, and Security, emphasizing that sustainability remains central to all IAF activities, with a particular focus on ensuring the long-term viability of both the Earth and the space environment.

The IAF remains deeply committed to fostering international cooperation, promoting sustainable practices in space activities, and contributing to global climate action through the application of space technologies and innovation.

2025 CHINA SPACE CONFERENCE

23 - 26 April 2025
Shanghai, China

The IAF Executive Director, Christian Feichtinger, was invited by the China National Space Administration (CNSA) and the Chinese Society of Astronautics (CSA) to attend the 2025 Space Day of China, organized by CNSA, and the 2025 China Space Conference, organized by CSA on 23-26 April in Shanghai, China.

At the Conference, Christian Feichtinger delivered a keynote address titled *"Guardians of Earth: How IAF Supports Climate Action"*. He highlighted the over 40 years fruitful cooperation between the IAF and China's space industry during which the Federation has witnessed China's remarkable advancements in space exploration. In light of today's pressing global challenges, such as climate change monitoring, asteroid defense, and the search for extraterrestrial life, he emphasized the need for a platform among scientists that facilitates the exchange of ideas across borders and helps build a consensus on shared responsibilities.

In addition, the IAF Executive Director participated in the Flying to Deep Space-International Science and Innovation Cooperation and Development Forum. In his greeting remarks, he emphasized the significance of the IAF Space Universities CubeSat Challenge (SUCC) in nurturing young talents. This initiative is a joint effort of the IAF and CSA.

GEO GLOBAL FORUM 2025

5 - 9 May 2025
Rome, Italy

The inaugural GEO Global Forum 2025 themed "The Earth Talks" focused on demonstrating how Earth observations can be a transformative tool in achieving the Sustainable Development Goals (SDGs). The event provided concrete examples and facilitated strategic discussions on how Earth Intelligence can support actions in areas such as ecosystem restoration, food security, disaster prevention, and climate resilience.

Central to the week's programme was the GEO-20 Plenary, which marked three significant milestones: the launch of the GEO Global Forum as a platform to advance "Earth Intelligence for All", the celebration of GEO's 20th anniversary, and the formal adoption of the Post-2025 Strategy Implementation Plan, which sets the strategic path forward.

Gabriella Arrigo, the Incoming President of the International Astronautical Federation (IAF), participated in the Plenary, highlighting the strengthened collaboration between the space sector and the Earth observation community.

The GEO Global Forum 2025 not only showcased the potential of Earth observations in addressing global challenges but also established a collaborative framework for future initiatives such as GLOC 2026 - the IAF Global Space Conference on Climate Change, which will be held from 2-4 June 2026 in Kigali, Rwanda.

2ND INTERNATIONAL WORKSHOP ON KEY ISSUES OF MANNED AND ROBOTIC DEEP SPACE EXPLORATION

2 - 6 June 2025
Xi'an, China

The 2nd International Workshop on Key Issues of Manned and Robotic Deep Space Exploration took place from 2 to 6 June 2025 in Xi'an, China. Organized by the China Aerospace Science and Technology Corporation (CASC), the Chinese Academy of Space Technology (CAST), and Xidian University, the event brought together global experts to discuss critical scientific, technical, and policy challenges in deep space exploration.

The event featured four thematic forums, addressing key topics such as next-generation space observatories, solar system robotic exploration, human spaceflight missions, and the development of international policies and standards for sustainable exploration.

The International Astronautical Federation (IAF) participated actively, with IAF Executive Director Christian Feichtinger delivering a keynote address. In his speech, Christian Feichtinger highlighted the IAF's commitment to fostering global cooperation in space exploration and emphasized the importance of collective efforts to advance sustainable and inclusive space activities. His remarks reinforced the IAF's role as a vital platform for international dialogue and collaboration across all domains of space science and technology.

AFRICA SPACE ECONOMY CONFERENCE 2025

17 - 19 June 2025
Abuja, Nigeria

The second edition of the Africa Space Economy Conference and Exhibition themed *"Space Economy and Emerging Market in Africa"*, co-organized by the Abuja Chamber of Commerce and Industry (ACCI) and the National Space Research and Development Agency (NASRDA), gathered government officials, industry leaders, and academics to explore how space technologies can accelerate sustainable growth and innovation across Africa.

IAF President Clay Mowry delivered a keynote address highlighting the importance of international cooperation and the establishment of regional space hubs to attract investment and build local capacity. Also participating as speakers were Marlene M. Losier, representing the IAF Committee on Liaison with International Organizations and Developing Nations (CLIODN), and Imane El Khantouti, Vice-Chair of the IAF Committee on Connecting Emerging Space ecoSystems (ACCESS) Africa Subcommittee.

2ND INTERNATIONAL DEEP SPACE EXPLORATION CONFERENCE (TIANDU FORUM)

18 - 22 June 2025
Shenzhen, China

The 2025 China (Shenzhen) Aerospace Industry Conference, held from 18 to 22 June, gathered space leaders and industry representatives to explore the future of global aerospace development. The International Astronautical Federation (IAF) participated in this event, with IAF Executive Director Dr. Christian Feichtinger delivering a keynote speech titled *"Towards a United Spacefaring Future: Global Trends and IAF Driving Forces Fostering International Collaborations"*.

In his address, Christian Feichtinger highlighted key global trends, including the strengthening of international partnerships through joint missions like Artemis, ExoMars, and the International Lunar Research Station Cooperation Organization (ILRSCO). He also emphasized the renewed focus on human exploration of the Moon and Mars.

China continues to play a pivotal role in this global landscape. With 46 IAF Proud Members, China ranks second among all countries in IAF membership, illustrating its strong and growing commitment to space exploration and innovation.

The conference underscored the importance of global dialogue, mutual understanding, and collaborative progress - principles that are central to the IAF's vision for a united spacefaring future.

ESA'S LIVING PLANET SYMPOSIUM 2025

23 - 24 June 2025
Vienna, Austria

On 24 June 2025, the International Astronautical Federation (IAF) took part in the high-level international plenary session *"Breaking Barriers by Working Together in Earth Science"*, held during ESA's Living Planet Symposium (LPS25) in Vienna. This session convened leading space agencies and organizations to reflect on the challenges and successes in fostering global cooperation in Earth observation (EO).

Representing the IAF, Executive Director Christian Feichtinger joined a distinguished panel of experts from NASA, JAXA, GISTDA, PhilSA, UNOOSA, the African Space Council, and UKSA. Moderated by Rune Floberghagen and Marie-Claire Greening of ESA, the session focused on strategies for overcoming institutional, technical, and policy-related barriers to building sustainable and impactful partnerships.

"As a neutral platform, the IAF brings together government, industry, academia, and emerging space actors", Christian Feichtinger emphasized, *"helping create the trust and continuity needed to build long-lasting international collaborations in EO and beyond"*.

The session served as a powerful reminder that advancing Earth science and responding to climate challenges requires a collective, coordinated approach. The IAF remains dedicated to facilitating this dialogue and strengthening connections across the global EO community.

68TH SESSION OF THE UNITED NATIONAS COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE (UN COPUOS)

25 June - 2 July 2025
Vienna, Austria

From 25 June to 2 July 2025, the 68th Session of the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS) convened in Vienna, Austria, uniting global stakeholders to address key issues in international space cooperation.

At this session, the International Astronautical Federation (IAF) delegation, led by Executive Director Christian Feichtinger, delivered a statement under the General Exchange of Views, highlighting the Federation's recent initiatives and strategic vision. Christian Feichtinger announced that the 32nd edition of the IAF Workshop, supported by the United Nations Office for Outer Space Affairs (UNOOSA) under the theme "*Resilient Coasts, Resilient Earth: Innovative Space Solutions for Coastal Resilience and Emergency Management"*, will take place from 26 to 28 September 2025 in conjunction with the IAC 2025 in Sydney, Australia. This year's call attracted 274 applications from 75 countries, underscoring the commitment of both the IAF and UNOOSA to engage emerging space nations and promote space-based solutions for sustainable development.

In addition, the IAF announced the next IAF Global Space Conference on Climate Change (GLOC 2026), to be held in Kigali, Rwanda, 2 - 4 June 2026, and hosted by the Rwanda Space Agency. This event illustrates the Federation's dedication to fostering inclusive global dialogue and addressing climate change challenges through space technologies.

On the occasion of the 68th UN COPUOS session, the IAF delegation also attended a reception at the Australian Ambassador's Residence in Vienna, hosted by the Government of New South Wales and the Australian Space Agency aimed at warmly welcome international delegations ahead of the 76th International Astronautical Congress (IAC 2025) in Sydney.

3RD UN HIGH-LEVEL EXPERT GROUP MEETING ON BIG DATA AND FRONTIER TECHNOLOGIES FOR THE PLANET

8 - 10 July 2025
Frascati (Rome), Italy

The Third Meeting of the High-Level Expert Group on Big Data, titled *"Towards A Big Data Revolution for the Planet from Uncertainty to Opportunity,"* took place in Rome in July 2025. This event, organized by the United Nations Science-Policy-Business Forum on the Environment and Data for the Environment Alliance (DEAL), was co-hosted by Italy's Institute for Environmental Protection and Research (ISPRA) and the European Space Agency (ESA).

Leading experts from governments, UN agencies, space and research institutions, the private sector, finance, civil society, and academia gathered to discuss how high-integrity environmental data could propel global sustainability, enhance transparency, and foster green economic transformation. Key topics included advancing governance for the upcoming Global Environmental Data Strategy, integrating environmental data into the Global Digital Compact, leveraging data to boost green investment and accountability, and tackling emerging challenges linked to geopolitical shifts, new industries, and evolving data needs. The discussions set the stage for stronger international cooperation and more effective data systems to guide environmental decision-making.

ASCEND 2025

Las Vegas, United States
22 - 24 July 2025

ASCEND 2025 is the event uniting global community in continuous dialogue about our shared future beyond Earth.

This year, the International Astronautical Federation (IAF) proudly took part in the ASCEND 2025 gathering, where Charles-Aimé Nzeussi Mbouendeu, Chair of the IAF ACCESS Africa Subcommittee, joined a powerful lineup of ASCENDANTS - emerging leaders tackling the urgent challenges facing space sustainability and inclusion.

Under the guiding theme of "Space for All", Charles-Aimé delivered a thought-provoking talk addressing the climate crisis, global inequality, and the risk of replicating exclusionary systems as we expand into space. He emphasized that space sustainability must go beyond orbital debris mitigation - it must ensure that space remains a shared, inclusive, and generative domain for all nations and communities, especially those historically left behind.

6TH G20 SPACE ECONOMY LEADERS MEETING (SELM)

Hermanus, South Africa
1 - 3 September 2025

The 6th Space Economy Leaders Meeting (SELM), held in Hermanus, South Africa under the theme *"Space as a Catalyst for Inclusive Global Economic Development: Policy, Partnership and Prosperity"*, took place under the Chairmanship of the South African National Space Agency (SANSA).

The IAF Executive Director contributed to the discussions on the priority statements - Policy Alignment for the SDGs, Public-Private Collaboration and Knowledge Transfer, and Sustainable Space Operations - emphasizing space as a driver of inclusive global progress. Christian Feichtinger underscored the importance of coherent policy frameworks that align space governance with the Sustainable Development Goals (SDGs), foster stronger collaboration between public and private actors, and ensure that space activities are conducted responsibly and sustainably.

As an international forum that brings together representatives of the G20 member states to discuss and promote the development of the space economy, SELM provides a vital platform for advancing shared priorities. In this context, the International Astronautical Federation (IAF), together with ITU and UNOOSA, plays an important role in advancing the global space agenda - strengthening connectivity and data sharing, fostering dialogue and capacity building, and promoting inclusive international cooperation for the long-term sustainability of space activities.

3RD INTERNATIONAL DEEP SPACE EXPLORATION CONFERENCE (TIANDU FORUM)

Heifei, China
3 - 5 September 2025

The 3rd Tiandu Forum convened in Hefei, China, addressing the engineering planning of China's deep space exploration and promoting in-depth cooperation on international Large-Scaled Science Project.

A key focus of the meeting was planetary defense. The Asteroid Defense sub-forum highlighted China's growing engagement in this field, including its planned asteroid deflection test in 2027, an initiative underscoring the importance of global cooperation in protecting Earth from potential threats.

IAF Executive Director Christian Feichtinger delivered a presentation on *"Planetary Defense: Turning Science into Global Security"*, outlining global efforts to safeguard Earth from Near-Earth Objects (NEOs). He emphasized emerging trends such as lunar and Mars exploration, the integration of AI and big data, youth engagement, and orbital debris management. The presentation showcased the IAF's commitment to fostering dialogue, capacity-building, and collaboration on planetary defense through its NEO Technical Committee to advance international response capabilities.

6TH SCITECH FORUM ON SPACE ENGINEERING AND OPERATIONS SUPPORT

Moscow, Russia
2 - 4 December 2025

The International Astronautical Federation (IAF) had the honour to welcome participants at the 6th SciTech Forum on Space Engineering and Operations Support.

The SciTech Forum, organized by the Russian Academy of Sciences (RAS) and the RUDN University, brought together experts from academia, research institutions and industry from across five continents. The Forum addressed a wide range of critical themes including mission operations, space engineering, propulsion systems, Earth observation, and space sensors. The International Programme Committee reflected global diversity with particular engagement from BRICS nations and emerging space actors.

The IAF Executive Director Chrisitan Feichtinger addressed the delegates recognizing the longstanding involvement of both institutions within the IAF community. The RUDN University and the Russian Academy of Sciences have been proud IAF members since 2016 and 2024 respectively.

A special acknowledgement was extended to Sergey Krikalev, the renowned cosmonaut and valued member of the IAF Astronauts Administrative Committee, whose contributions continue to inspire space professionals worldwide.

Christian Feichtinger emphasized that with its proud 76-year history the Federation is committed to connect the world's space community. He also emphasized the IAF's dedication to supporting emerging space nations and facilitating opportunities for visibility, knowledge exchange, and integration into the global space ecosystem.

THE INTERNATIONAL ASTRONAUTICAL FEDERATION

Connecting @ll Space People

WHO WE ARE

Founded in 1951, the International Astronautical Federation (IAF) is the world's leading space advocacy body with 604 members from 82 countries including all leading space agencies, space companies, industries, research institutions, universities, societies, associations, institutes and museums worldwide.

Following its motto ***"Connecting @ll Space People"*** and its vision of *"a space-faring world cooperating for the benefit of humanity"*, the Federation advances knowledge about space, supporting the development and application of space assets by promoting global cooperation. As organizer of the annual International Astronautical Congress (IAC) as well as other thematic conferences and workshops, the IAF actively encourages the development of space activities for peaceful purposes and supports the dissemination of scientific and technical information related to space.

WHAT WE DO

- **Promoting cooperation**
- **Advancing international development**
- **Sharing knowledge**
- **Recognizing achievements**
- **Preparing the workforce of tomorrow**
- **Raising awareness**

BECOME A MEMBER

Membership in the IAF is open to all companies and organizations working in space-related fields.

If you are interested in becoming a member, please complete the "Application for IAF Membership" form (which can be found on our website: http://www.iafastro.org/membership) and send it together with your company's by-law, statutes and any other requested material to the IAF Secretariat.

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THE IAF SECRETARIAT TEAM

The IAF Secretariat is a small dynamic team based in Paris, France. We work hard every day with unwavering enthusiasm to ensure a smooth coordination and management of all IAF activities and events.

IAF EVENTS 2026

Connecting @ll Space People

for a sustainable future

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