



**INTERNATIONAL  
ASTRONAUTICAL  
FEDERATION**

# IAF HIGHLIGHTS

# 2022



***Connecting @ll Space People***

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# Abbreviations

3G	Geography, Generation, Gender	JAXA	Japan Aerospace Exploration Agency
AEB	Brazilian Space Agency	JPL	Jet Propulsion Laboratory
AI	Artificial Intelligence	JWST	James Webb Space Telescope
AIAA	American Institute of Aeronautics and Astronautics	LCNS	Lunar Communication and Navigation Service
ALCE	Latin American and Caribbean Space Agency	LCRD	Laser Communications Relay Demonstration
API	Application Programming Interface	LEO	Low-Earth Orbit
ASI	Italian Space Agency	LTS	Long-term Sustainability
CLIODN	Committee for Liaison with International Organisations and Developing Nations	MMoP	International Meeting for Ministers and Members of Parliaments
CNSA	China National Space Administration	MMX	Martian Moons eXploration
COSO	Committee of Sponsoring Organizations	MTG	Meteosat Third Generation
COPUOS	Committee on the Peaceful Uses of Outer Space	NASA	National Aeronautics and Space Administration
CSA	Canadian Space Agency	NEO	Near-Earth Object
CNES	Centre National d'Etudes Spatiales	NLP	Natural Language Processing
DART	Double Asteroid Redirection Test	NOSA	Norwegian Space Agency
DLR	German Aerospace Center	NSIL	NewSpace India Limited
EO	Earth Observation	OSAM	On-orbit Servicing, Assembly, and Manufacturing
ESA	European Space Agency	PNT	Positioning, Navigation and Timing
ESOC	European Space Operations Centre	PPP	Public-Private Partnerships
EVAs	Extravehicular Activities	QKD	Quantum Key Distribution
FAA	Federal Aviation Administration	R&D	Research and Development
GNSS	Global Navigation Satellite System	SAR	Search and Rescue
GPS	Global Positioning System	SDGs	Sustainable Development Goals
GRC	Governance, Risk and Compliance	SDR	Software Defined Radio
HSF	Human Spaceflight	SLS	Space Launch System
IADC	Inter-Agency Space Debris Coordination Committee	SOCA	Space Operations Committees Alumni
IAF GNF	Global Networking Forum	SpS	Special Sessions
ISEP	IAF Space Economic Platform	SRM	Solid Rocket Motor
ISO	International Organization for Standardization	STEM	Science, Technology, Engineering and Mathematics
ISRO	Indian Space Research Organisation	SWOT	Surface Water and Ocean Topography
ISS	International Space Station	TC	Technical Committee
ISU	International Space University	UN	United Nations
ITU	International Telecommunication Union	WG	Working Groups

# Welcome Message



As we bid farewell to 2022, I am both excited and proud to have begun my three-year term as president of our Federation. I formally took the reins from Pascale Ehrenfreund at the record-setting IAC 2022 Closing Ceremony in Paris. Let me express my sincere admiration for Pascale's incredible work leading the IAF during challenging times. She has guided the world's largest international space organization through a period of rapid changes, adapting our programming during the global pandemic and achieving unprecedented success at the 73<sup>rd</sup> IAC. It is a true honour to follow in her footsteps and continue building on her exceptional efforts.

The year 2022 has been an outstanding year for the IAF with several noted and successful events. We started in March celebrating the Federation's 70<sup>th</sup> Anniversary in Paris. This beautiful event was a wonderful occasion to bring together the IAF community to celebrate the Federation's long history and

chart a course for the future. The organization's platinum anniversary was followed by the first in-person IAF Spring Meetings since the start of the pandemic.

The second edition of the Global Conference on Space for Emerging Countries (GLEC 2022) was organized together with the Sideralis Foundation in Quito, Ecuador in May 2022. The inclusion of emerging space nations is of great importance and one of the key missions for the Federation. This was the first IAF event ever organized in Ecuador. The robust dialogue and incredible hospitality of our Ecuadorian hosts was impressive. Seeing the positive impact and legacy the GLEC left in the region is truly fantastic.

In September, the 73<sup>rd</sup> International Astronautical Congress was organized in Paris, France. IAC 2022 exceeded all expectations with more than 9,370 delegates from 110 countries attending the event, making it the largest IAC ever held. Hosted by the Centre National d'Études Spatiales (CNES) under the theme "Space for @ll", the IAC 2022 aimed to reach beyond the usual space community and bring together the space and non-space sector, providing the opportunity to network, discuss and forging new partnerships across sectors. IAC 2022 also made history as the first environmentally sustainable IAC.

Looking forward to 2023, we are inviting you to join our first Global Space Conference dedicated to Climate Change (GLOC 2023) in Oslo, Norway and the 74<sup>th</sup> International Astronautical Congress (IAC 2023) in the magical city of Baku, Azerbaijan.

Finally, we are jump starting my agenda for the coming three years as an IAF President, focusing on the topics of Sustainability, Investment and Security. We have organized three task forces that will work to expand programming on the themes for IAF events. I am looking forward to be collaborating with all of you on this new chapter for the Federation.

I would like to wish everyone a wonderful and joyful holiday season, and a prosperous 2023!

## Clay Mowry

President,  
International Astronautical Federation (IAF)

# IAF 2022

## Events Overview



# IAF General Assembly Report 2022

The International Astronautical Federation General Assembly has gathered during the International Astronautical Congress, IAC 2022 in Paris, France in two sessions (Sunday, 18 September 2022, and Thursday, 22 September 2022).

## 2022 Elections of IAF Officers

Four new Vice-Presidents have been elected by the General Assembly:



**Mishaal ASHEMIMRY**, Aerospace Consultant & Special Advisor to CEO, Saudi Space Commission (SSC), has been appointed as IAF VP for **Diversity Initiatives**



**Anil KUMAR**, Associate Director, ISTRAC and Chief General Manager, Safe & Sustainable Space Operations Management, Indian Space Research Organisation (ISRO), has been appointed as IAF VP for **Relations with International Organizations**



**Tanja MASSON-ZWAAN**, Assistant Professor and Deputy Director of the International Institute of Air and Space Law (IIASL), Leiden University, has been appointed as IAF VP for **Science and Academic Relations**



**Pilar ZAMORA ACEVEDO**, Executive Director, Colombian Space Agency (AEC), has been appointed as IAF VP for **Developing Countries and Emerging Communities**

In addition, President Clay Mowry has nominated the following Special Advisors:

- **Joe LANDON**, Vice President & General Manager, Lunar Infrastructure Services, Lockheed Martin Corporation, as Special Advisor **Special Advisor to the President on the Sustainability, Investment and Security (SIS) Agenda**



- **Dominique TILMANS**, President, EURISY, as Special Advisor **Special Advisor to the President on Parliamentary and Ministerial Relations**
- **S. SOMANATH**, Chairman, Indian Space Research Organisation (ISRO), as **Special Advisor to the President on Space Agencies Relations**
- **Giorgio SACCOCCIA**, President, Italian Space Agency (ASI), as **Special Advisor to the President on the International Space Forum (ISF)**

## Selection of Host City for IAC 2025

The IAF General Assembly at its second session on 22 September 2022, selected Sydney, Australia, as Host City for IAC 2025. The Hosting Organization is the Space Industry Association of Australia (SIAA), an IAF member since 2012.



## IAF Finance

The IAF has also approved the **final accounts 2021 and Auditor's Statement 2021** and the **revised budget and preliminary accounts 2022** and the **Proposed Budget 2023**.

## New IAF Members

The IAF General Assembly also approved the applications of **45 new Member Organizations**. With this, the IAF Membership comprises **468 Member Organizations** from **75 countries**, bringing 4 new countries in the Federation Members' community, Monaco, Greece, Iceland and Rwanda, re-confirming IAF's position as a truly global Federation.

The New IAF Members are:

Organization	Category	Region	Country
Alén Space, S.L	Space Industry	Spain	Europe
ALTEC Spa	Space Industry	Italy	Europe
American Institute of Physics	Association and Professional Societies	United States	North America
Andart Global	Space Industry	United Arab Emirates	Asia
Arizona State University	University	United States	North America
ArkEdge Space Inc.	Space Industry	Japan	Asia
C6 Launch Systems, Corporation	Space Industry	Canada	North America
Coactum	Space Industry	Switzerland	Europe
Dhruva Space Private Limited	Space Industry	India	Asia
EMPOSAT CO., LTD	Space Industry	China	Asia
Equatorial Launch Australia Pty Ltd	Space Industry	Australia	Oceania
Eutelsat	Space Industry	France	Europe
For all Moonkind Inc.	R&D Organization	United States	Europe
Habitat Company GR	R&D Organization	Mexico	Latin America
Hellenic Space Centre	Space Agency	Greece	Europe
Iceland Space Agency	Space Agency	Iceland	Europe
Idea Space	Space Industry	Brazil	Latin America
Institut Polytechnique des Sciences Avancées (IPSA)	University	France	Europe
Institute of Space Systems, University of Stuttgart	University	Germany	Europe
Isar Aerospace Technologies GmbH	Space Industry	Germany	Europe
Loft Orbital Solutions Inc	Space Industry	United States	North America
Łukasiewicz Research Network – Institute of Aviation (ILOT)	R&D Organization	Poland	Europe
Monaco Office of Space Affairs	Space Agency	Monaco	Europe
National Space Society Colombia	Association and Professional Societies	Colombia	Latin America
Orbital Express Launch Limited (Orbex)	Space Industry	United Kingdom	Europe
Orion Applied Science & Technology, LLC	Space Industry	United States	North America
Plan-S Satellite and Space Technologies	R&D Organization	Turkey	Asia
Privateer Space, Inc.	Space Industry	United States	North America
QSTC Inc.	Space Industry	Canada	North America
Redwire Space	Space Industry	United States	North America
Rwanda Space Agency	Space Agency	Rwanda	Africa
SAHA Istanbul Defence & Aerospace Cluster	Association and Professional Societies	Turkey	Asia
SDA Bocconi School of Management, Bocconi University	University	Italy	Europe
Shanghai Azimuth Data Technology	Space Industry	China	Asia
Sharjah Academy for Astronomy, Space Sciences, and Technology (SAASST)	University	United Arab Emirates	Asia
Space Arbitration Association	Association and Professional Societies	France	Europe
Space Renaissance International (SRI)	Association and Professional Societies	Italy	Europe
Space Research Institute (IKI), Russian Academy of Sciences (RAS)	R&D Organization	Russian Federation	Europe
STAR.VISION Aerospace Group Limited	Space Industry	China	Asia
Stichting Space Professionals Foundation (SSPF)	Association and Professional Societies	The Netherlands	Europe
The Exploration Company GmbH	Space Industry	Germany	Europe
UzayA Law and Science Association	Association and Professional Societies	Turkey	Asia
Viasat, Inc.	Space Industry	United States	North America
WeMe Global	Space Industry	Austria	Europe
Yinhe Hangtian (Beijing) Internet Technology Company Limited (GalaxySpace)	Space Industry	China	Asia



# IAF 70<sup>th</sup> Anniversary

Saturday 26 March 2022 | Paris, France



It was a great pleasure gathering the IAF community to commemorate the IAF 70<sup>th</sup> Anniversary in Paris on Saturday 26 March 2022, a truly important moment in the history of the International Astronautical Federation. Seventy years of connecting space people is an impressive milestone and something each and every one who has been part of the IAF should be very proud of.

The celebratory event took place at the stunning Intercontinental Hotel Le Grand and started off with welcome remarks by the IAF President Pascale Ehrenfreund, the Incoming IAF President Clay Mowry and CNES President Philippe Baptiste. Followed by the first panel “70 Years of Connecting Space People”. Current and past Presidents of

the Federation joined on stage to reflect and remember IAF’s rich history, until today’s outstanding achievements in an interesting panel discussion.

The second panel “An IAF Spaceflight to 2091” focused on IAF’s next 70 years, and joined together senior experts and young professionals to discuss the best ways in which the IAF will be able to continue playing a major role in the global space arena in the years to come, and eventually reach space by 2091.

The IAF 70<sup>th</sup> Anniversary celebration finished with an astonishing gala dinner.





# IAF Spring Meetings 2022

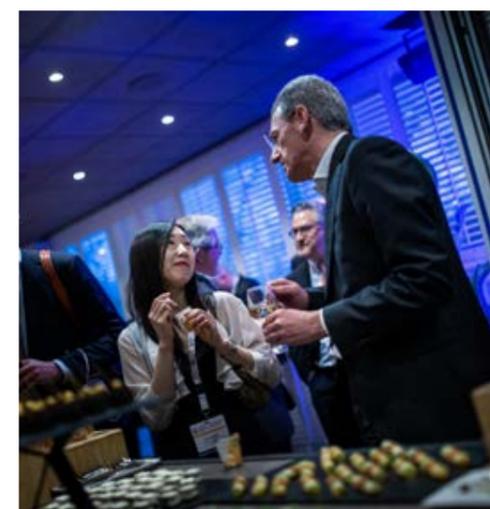


28 – 30 March 2022 | Paris, France



From 28 – 30 March 2022, the Bureau and members of the International Astronautical Federation (IAF) gathered in Paris, France for its annual Spring Meetings for the first time since 2019. Various events took place during the three days, including the selection of abstracts for IAC 2022; IAF “5G” Diversity events; committees’ meetings including two sessions of the IAF Bureau; and IAF GNF sessions.

The IAF Global Networking Forum featured inspiring sessions on the James Webb Space Telescope, the First International Moon Day, IAC 2023, GLEC 2022 and European Astronauts Manifesto. This was followed by the traditional IAF Cocktail. The IAF Spring Meetings finished off with a Press Conference on Wednesday afternoon.





# IAF Global Conference on Space for Emerging Countries

16 – 20 May 2022 | Quito, Ecuador



# GLEC 2022

## Opening Ceremony

*The second edition of the Global Conference on Space for Emerging Countries featured several global space leaders who spoke about the importance of international cooperation, building an inclusive global space sector, and Latin America's role in the future of space exploration and development.*

In the summer of 2019, the IAF hosted its first edition of the Global Conference on Space for Emerging Countries in Morocco. The event was a resounding success that highlighted the growing importance of emerging actors in the space sector and by the time the conference concluded many of its organizers and attendees were already making plans for a second conference. But no one could have imagined how dramatically the world would change just a few months later when the COVID-19 pandemic swept across the globe.

In May, the IAF hosted its second edition of GLEC in Quito, Ecuador. While the past two years have been exceptionally challenging for millions of people around the world, they have also revealed our incredible resiliency in the face of unprecedented hardship and nowhere is this more evident than the global space sector. During the past two years, we have seen national space agencies find creative solutions for managing missions in a remote work environment, we witnessed the formation of countless new space companies, and most importantly of all, we have

seen a dramatic increase in the size and diversity of the global space community.

The importance of collaboration and inclusion were the dominant themes of the GLEC 2022 opening ceremony that was presided over by IAF's Executive Director Christian Feichtinger. The ceremony began with a stunning performance by local dancers dressed in indigenous garments that was fittingly titled "The Beginning of the Universe." After this rousing performance, Ecuador's Vice Minister of Foreign Affairs Luis Vayas Valdivieso offered some words of welcome and was followed by Pascale Ehrenfreund, the President of the International Astronautical Federation (IAF), who highlighted the importance of the gathering in Ecuador for the conference.

"At a time when space activities are really undergoing an enormous transformation and technological innovations, the emergence of new actors and involving emerging nations has never been more essential," Ehrenfreund said. "It is the right place and time for emerging countries to



“At a time when space activities are really undergoing an enormous transformation and technological innovations, the emergence of new actors and involving emerging nations has never been more essential”

create a platform to initiate cooperation, join programmes, and jointly explore current and future opportunities.”

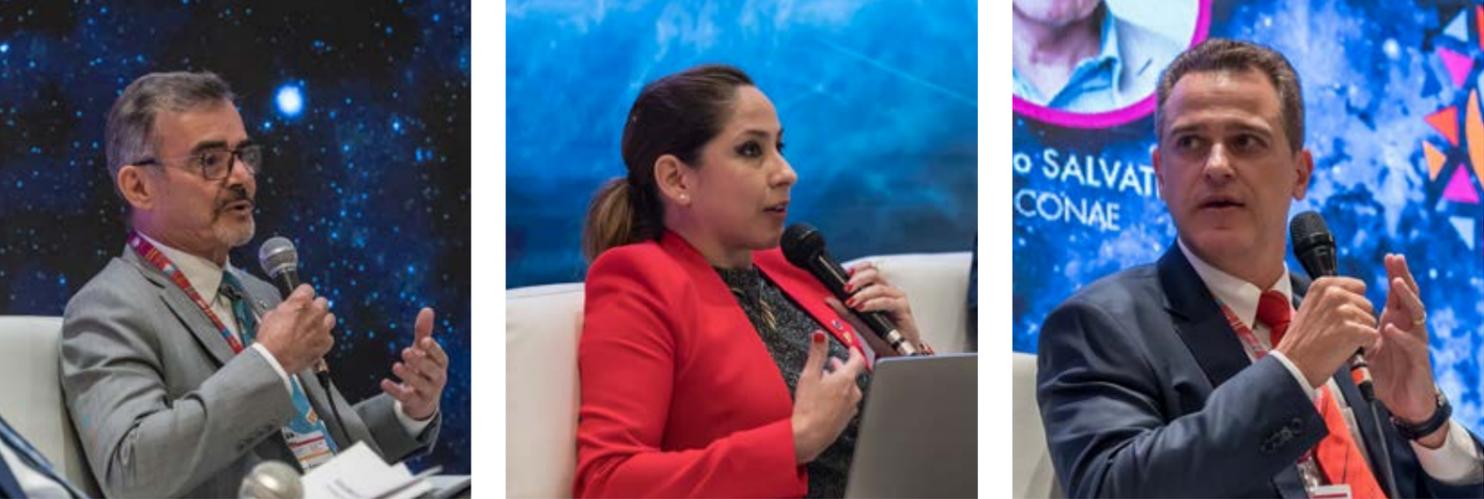
These sentiments were echoed by Juan Jaramillo Rojas, the President of the Sideralis Foundation, a member of the IAF and the host of GLEC 2022. Rojas stressed the importance of hosting the conference in Ecuador for inspiring students, teachers, and researchers in Ecuador, Latin America, and around the world to become leaders in the global sector. “We want to send the message to the world that we are ready to be an active part of this community through cooperation with the government and private sectors, not only in Ecuador, but across Latin America,” Rojas said.

Valanathan Munsami, the former CEO of South African National Space Agency (SANSA), Chancellor at International Space University (ISU), and GLEC 2022 IPC Co-Chair, spoke about the IAF's commitment to supporting the development of space capacities in emerging countries. He highlighted the IAF's principle of “3G” Diversity, which is enshrined in the organization's code of conduct and commits the IAF to inclusiveness in terms of geography, gender, and generations. He also congratulated participants involved in a new IAF committee called the Latin American and Caribbean Working Group, whose first chair—Matias Campos—was elected the day before the start of GLEC.

Giorgio Saccoccia, the President of the Italian Space Agency, concluded the opening ceremony by discussing the critical importance of cooperation between emerging space nations and more mature space actors. He pointed to the critical role that these collaborations played in the development of Italy's own national space programme and expressed his hope that the conference would produce more such collaborations between the more than 40 countries in attendance.

“The countries that only have a short experience in space activities can take the best of the long experience that other countries have built up to contribute and go beyond to prepare a solid and sustainable future for space activities,” Saccoccia said. “I'm sure this conference will give you a great opportunity for expansion, for exchange, and to get inspired.” ■





## High Level Panel: The Role Of Space Agencies in a Space Ecosystem

*The first plenary of GLEC 2022 was a high level panel divided in two parts. Part 1 A featured the heads and representatives of several space agencies, who discussed the role of space agencies in the space ecosystem.*

# GLEC 2022 Plenaries



The first plenary of GLEC 2022 featured the heads and representatives space agencies, who discussed the role of space agencies in the space ecosystem in a conversation moderated by Pascale Ehrenfreund, the President of the International Astronautical Federation (IAF).

Pilar Zamora Acevedo, the Executive Director of the Colombian Space Agency (AEC), initiated the panel by discussing Colombia's space activities and the role of its national space agency in fostering these programmes. Acevedo highlighted the importance of public participation in the Colombian space programme in order to orient it toward social needs. The importance of agriculture in Colombia, for example, has resulted in the prioritization of space projects that support farmers and other agricultural workers. Acevedo also touched upon the importance of education in developing a space programme, a theme that came up throughout the panel. As Acevedo said, "It all starts with education."

Luis Alfaro, the President and CEO of the El Salvador Aerospace Institute, emphasized the importance of strong market policy to attract industry and foreign investment into the country's space sector as well as the critical role of fostering knowledge for space development. He also singled out the role of international cooperation, which is critical for advancing both private and public sector space initiatives. Through the integration of academia, private industry, and government programmes, Alfaro said, El Salvador has been able to lay the foundation for developing its own space technology and building the knowledge and industrial base for participating in the space activities of partner nations.

Fuad Aslanov, the Vice Chairman of the Azercosmos Space Agency of the Republic of Azerbaijan, spoke about the country's experience building its space agency since it was founded in 2010. In particular, he focused on how the country grew from a relatively narrow goal of becoming a satellite operator to provide services to Azerbaijan and other countries in its region to expand its space operations to larger and more ambitious projects. He highlighted the important knowledge and economic advantages gained through the operation of the country's first telecommunications satellite, which now generates more than 90% of its revenue providing services to countries other than Azerbaijan. Like Alfaro, he emphasized the importance of

“We believe this is extremely important, especially nowadays with all the developments in the new space sector”



international cooperation and developing technology in Azerbaijan rather than just consuming it. "We believe this is extremely important, especially nowadays with all the developments in the new space sector," Aslanov said.

Christian Hauglie-Hanssen, the Director General of the Norwegian Space Agency (NOSA), spoke about how the most important thing for a developing space agency to do is to define its ecosystem. As Hauglie-Hanssen pointed out, a national space policy requires a specific purpose to make it worthwhile. "Unless you have a defined policy or a defined strategy, talking about the role of the space agency does not really make sense," he said. In Norway, for example, the space agency is currently conducting a comparative study on the space policies of other nations to examine how they are approaching the market and how these experiences





can guide Norway’s own space policy and support the development of a national space industry.

Shri Sankaran, the Director U R Rao Satellite Centre at the Indian Space Research Organization (ISRO), spoke about the lessons that India’s space agency had learned over its past 60 years of organization. According to Sankaran, India’s space agency started by identifying applications for space technology and then began building the network infrastructure to achieve those applications. In the case of India, this meant with starting to build the ground infrastructure to use a satellite before working on building its own satellites and launch vehicles. Once those objectives were achieved, the ISRO was able to use its knowledge to support the development of an Indian private space sector to increase the country’s space capabilities and provide critical services to the government space programme. “What a space agency has to do to create a vibrant space ecosystem is act as the fulcrum of national space activities,” Sankaran said. “It should focus on R&D and technology development, while the more commercial activities can be carried out by industries.”

Anthony Tsougranis, the Europe Team Lead at NASA, highlighted six important roles for national space agencies everywhere. The first role is to form a space policy by educating governments about the role of the space sector in achieving national objectives. The second role is to educate, advocate, and inspire the general public about space activities. The third role is to execute successful missions and learn from failure. The fourth is to create jobs in local economies and help solve social problems for the country’s citizens. The fifth is to build bridges between countries through cooperative space efforts in both the public and private sector. The final role of space agencies, according to Tsougranis, is to focus on programmes that are in the public good, namely programmes that are too expensive or complicated to be carried out by the private sector. “Every space agency can contribute something,” Tsougranis said. “There are ideas to be found, there are discoveries to be made, and there are problems to be solved, and space agencies are positioned in the space ecosystem to do exactly that.”

The final speaker on the plenary panel was Grzegorz Wrochna, the President of the Polish Space Agency (POLSA), who discussed the agency’s progress during its first eight years of existence. In addition to launching its own 10 satellites, the Polish Space Agency has cooperated on more than 80 missions with other space agencies that range from missions to the sun to missions to Mars. At the same time, Poland has spurred the creation of more than 400 space companies in the country, most of which are small and medium-sized businesses. He emphasized the important role that new technologies have played in making ambitious programmes viable for young space agencies, such as small satellites and commodity components. “We don’t need to follow the history of big agencies and organize everything from scratch,” Wrochna said. “The role of the new young space agencies is the role of the integrator.”



## High Level Panel: The Role Of Space Agencies in a Space Ecosystem

*The second part of plenary 1 of GLEC 2022 featured the heads of four space agencies and several policy makers involved in national space activities, who discussed the role of space agencies in the space ecosystem.*

The second part of plenary 1 of GLEC 2022 featured the heads of four space agencies and several policy makers involved in national space activities, who discussed the role of space agencies in the space ecosystem. This sister panel to the first plenary was moderated by Steve Eisenhart, the Senior Vice President of the Space Foundation, who led a conversation that touched on several key themes including education, cooperation, and the interactions between public space agencies and the private sector.

Carlos Augusto Teixeira de Moura, the President of the Brazilian Space Agency (AEB), led the conversation by discussing how the country’s space activities have evolved over the past 60 years. Although Brazil’s space agency is only 28 years old, it has been participating in space activities through partnerships with NASA and

other space organizations since the 1960s. During that time Brazil has launched several large-scale satellites, both on its own and in partnership with other countries, but Teixeira de Moura highlighted the difficulty of funding these large projects through a solely publicly run space programme. One of the biggest changes for Brazil’s space agency over the past few years has been an increased emphasis on connecting its entrepreneurs with the global space community to foster a robust private sector that can generate value for the country and its people by engaging in space activities. “We have new opportunities to go to space and to do applications faster and with lower cost,” Teixeira de Moura said. “So the paradigm is changing and the Brazilian Space Agency is in the middle of that.”



Guillermo Salvatierra, a member of Board of Directors on Argentina's Comision Nacional de Actividades Especiales, spoke about how the history of the country's space agency since it was created in 1991 and how its focus has changed over the past 30 years. In the beginning of Argentina's space agency, Salvatierra said, it was very focused on cooperating with international partners like NASA to develop the expertise and industrial capacity it needed to develop its own national space sector. As those capabilities increased, Argentina managed to build four of its own satellites that currently provide Earth observation and telecommunications services for the country. Yet creating this industrial base turned out to create its own challenges, Salvatierra said, because today the country has many strong space companies that are serving the private sector, but lacks the human resources to expand its national space sector. He cautioned that this is a development that emerging space agencies should be aware of as they work to build up national space capabilities.

Mary Preville, the Vice President of Space Program Policy at the Canadian Space Agency (CSA), discussed how the space agency has evolved over its 60 year history and

how it has adapted to rapidly changing developments in the private sector in particular. While Canada was the third country to place an asset in space, its space agency is still considered small and focuses on a few core areas of expertise such as exploration, a human space flight program, and Earth observation. Importantly, Preville said, the Canadian Space Agency made a conscious decision early on not to focus on manufacturing and physical integration. Instead, it delegated these activities to the private sector to spur a domestic space industry for economic benefit. Like her colleagues on the panel, Preville emphasized the importance of international and public-private cooperation for national space agencies. However, she said this role is changing rapidly as space agencies learn to work with international space companies as opposed to only companies within their borders. At the same time, she said, the Canadian Space Agency is focusing on new ways to spur industry development through competitive funding arrangement to achieve national objectives. For example, the Canadian Space Agency has recently launched a programme to challenge its space industry to figure out techniques for monitoring endangered North Atlantic righth whales from space.

Giorgio Saccoccia, the President of the Italian Space Agency (ASI), focused on how the country's space programme has been used as an engine for economic growth. "Never underestimate the potential of space to push economic growth and also education," Saccoccia said. Part of this process of using space for economic development is seizing opportunities to collaborate with more mature space programmes in other countries to develop space capabilities domestically. In particular, he highlighted the role of events such as the International Space Forum to connect space actors from across the planet and advance the cause of the space sector in countries who do not have a history of space activities. "I think this is very, very important because something that we need to do as countries with more tradition in space is to explain to new countries how to convince their political system about the importance of space," Saccoccia said. "Of course, the best way to do this is to share our experience."

Michal Brichta, the Head of the Slovak Investment and Trade Development Agency in the Slovak Space Office, spoke about how the country's participation in the space ecosystem has changed since the 1970s, particularly with the growth of government support over the past few years after the Slovak Space Office was officially established. "It started as sort of a bottom-up approach even though they were governmentally led because the whole idea was to tackle the challenges that the ecosystem was facing," Brichta said. He identified two main challenges addressed by the Slovak Space Office, namely finding opportunities for collaboration in the space ecosystem and the limited knowledge about Slovak capabilities from potential international partners. To address these challenges, the Slovak Space Office began offering support to help new companies enter the space sector while working actively on fostering partnerships with international collaborators. The results, he said, have been spectacular: In the first three years of the Slovak Space Office's existence, the size of its national space ecosystem has nearly doubled in terms of the number of operating companies.

The final speaker on the panel was Serdar Hüseyin Yildirim, the President of the Turkish Space Agency (TUA), who spoke about the critical importance of creating a national space ecosystem. In particular, he highlighted the role of the government in funding R&D for complex technical projects in the absence of an established private space sector and deep academic community working in space. To counter these challenges, Turkey unveiled its National Space Program last year that was focused on building a national ecosystem that consists of both private sector and government initiatives. Since Turkey does not have a large enough economy to currently support private space companies that build their own rockets and satellites, Yildirim said that international collaboration was key to building up Turkey's domestic space capabilities. "When we come together with other emerging economies and the nations in the space sector, then we see that there are many opportunities," Yildirim said. "We can make use of the capacities which are existing on their side or our side and combine them so we are more capable of doing big projects."



“Never underestimate the potential of space to push economic growth and also education”



## High Level Panel: The Role Of Space Industries in a Space Ecosystem

*The second plenary of GLEC 2022 brought together eight business leaders whose work spans the spectrum of space activities to speak about the role of space industries in a space ecosystem.*

The panel was moderated by Clay Mowry, the Chief Revenue Officer at Voyager Space Holdings and Incoming IAF President, who led a conversation that touched upon how private investment is shaping space activities, the role of new technologies for supporting space startups, and other factors that are lowering the barrier to commercial space. Mowry initiated the conversation by discussing the three main properties of a thriving commercial space ecosystem, namely self-organization, scalability, and sustainability. “This is a seminal moment in space,” Mowry said. “You see a ton of companies at many levels that are now coming to space with real products and services that heretofore were the purview of nation states.”

Matias Campos, the CEO and Founder of Astralintu Space Technologies, discussed the importance of space CEOs taking a regional perspective on the industry. This, he said, is something that is deeply relevant to his own company, which is the only new space company in Ecuador. “There’s not much of an ecosystem,” Campos said. “But if we stop thinking about only countries and think about the region, we have a really rich ecosystem in Latin America.” Campos also acknowledged the importance of the newly created Latin American and Caribbean subcommittee of the IAF, which recently elected him as the vice chair, for fostering further commercial space development throughout the region. “We think that’s the way to go to bring space benefits to our society,” he said.

Bruno Carvalho, the Director of D-Orbit Portugal, spoke about the importance of creating sustainable supply chains for the commercial space ecosystem. One part of this,

Carvalho said, is developing partnerships on the ground to create space products and services as part of what he called a “distributed space approach.” The other part of a sustainable supply chain, according to Carvalho, is in space, which means developing the capabilities to deploy resources in Earth orbit and beyond, which will open up new capabilities on the Moon, Mars, and asteroids. “Linking that together is certainly a challenge,” Carvalho said, comparing the challenges faced by the space supply chain to those faced by the maritime sector. “It’s really about the partnerships you create, the trust, help and support you need to build beneficial relations for all the entities involved.”

Christopher Geiger, the Internal Audit Director at Lockheed Martin Corporation, highlighted the importance of infrastructure for building a robust commercial space ecosystem. One major shift that Geiger noted was the transition from building large space projects as an individual company to participating in larger projects in a collaborative fashion. “This is really a time to take those technologies and bring them to a lot more customers,” Geiger said. “So instead of having to purchase an entire asset, you can share time on it, whether it’s on the Moon or a space station in low Earth orbit.” Geiger also touched on the important role played by private capital in the development of a space ecosystem, which he described as a new trend compared to the conventional way of developing space assets solely through government support.

Vincenzo Giorgio, the Vice President of Institutional Marketing and Sales at Thales Alenia Space Italia,

“This is really a time to take those technologies and bring them to a lot more customers”

discussed the role of space habitats in the future of the space ecosystem. He highlighted how the ability for private industry to take on significant projects like in-space habitats arose due to government direction and support to work on these types of projects decades ago. But in the past, Giorgio said, the paradigm was to build pressurized in-space modules for space agencies as standalone projects. Today, he said, the work done by Thales Alenia Space is focused more on a commercial service approach that involves collaboration between multiple companies to achieve a mutual goal. “We are able not only to build, but also to cooperate and participate with those enterprises,” Giorgio said. “We have completely changed our way of working.”

Joerg Kreisel, the CEO of JKIC, spoke about the future of commercial space and the key elements that are missing from the existing space ecosystem. Arguably the most important missing piece, said Kreisel, is space infrastructure to enable all the projects that are in the pipeline for various space agencies and private companies. An important feature of this infrastructure will be what Kreisel referred to as “OSAM” or On-orbit servicing assembly and manufacturing in space. The consequence of this, he said, is a move toward more modular systems across the space ecosystem. “If you consider future systems to be more flexible building blocks to do more for less and open up space for more private sector players, then you can see that design principles will be turned upside down,” Kreisel said. “We will move away from monolithic throwaway systems to modular systems which can be upgraded, maintained, serviced, repaired, and repurposed.”

Brian Lantier, the Executive VP of Global Sales at Satellogic Solutions SL, discussed more downstream aspects of the space ecosystem including user capability. Lantier spoke about how Satellogic, for example, provides data imagery, which is an important element for enabling the wider space ecosystem to grow. The idea, he said, is to reduce the barrier to entry and democratize access to these important kinds of data. “The idea is that we can now help national space agencies leapfrog from where they are now to where they could be in one year with respect to having access to space assets in orbit right now,” Lantier said. “The imagery and data we provide and the hosted payload capabilities we provide is now affordable and accessible to not just governments, but the commercial world as well.”



John Roth, the Vice President of Business Development at Sierra Space, focused on the importance of low cost and reliable access to space. Roth said that the commercial sector plays an important role not just in space access, but also in creating space destinations. “It’s never going to happen just by government funding,” he said. Roth sees equity capital playing a big role in developing future space access capabilities because it enforces a unique type of discipline on companies operating in the sector because they are looking for a profitable return on capital. This, in turn, drives innovation, faster timelines, and lower costs. “One of my pieces of advice to emerging space agencies is don’t think that you can spend a lot of money to create a commercial economy,” Roth said. “You really have to depend on commercial businesses bringing in outside equity money and relying on infrastructure that’s already out there.”

The final speaker for plenary 2 was Wei Sun, the President of International Business at the HEAD Aerospace Group, who spoke about how commercial space applications can improve life on Earth. Part of this process, said Sun, relies on natural market mechanics to drive applications. Space companies need a market, they need investors, and they need to generate profit and create the applications that are the foundation for a sustainable space ecosystem. “I think the most sustainable part of the space ecosystem is applications because there’s benefits to human beings in our day-to-day life,” Sun said. “From the point of view of a developing country, I think concentrating on applications is important for sustainability.”



## Space Law and Policy

*The third plenary session of GLEC 2022 featured a diverse cast of speakers from academia, space agencies, law firms, and commercial space businesses who offered their perspectives on the present and future of space law and policy.*

The session was moderated by Sergio Marchisio, Full Professor of International Law at Sapienza University of Rome, who opened the discussion by discussing two facets of space governance. First, there is the institutional face of space governance, which consists of all policies, programmes, and strategies, as well as the institutions that create them. The second facet is the normative aspect of space governance, which are aimed at implementing treaties that spacefaring nations have adopted.

Michelle Hanlon, the Co-Director of the Center of Air and Space Law at the University of Mississippi, opened the panel by discussing the concept of due regard as it is mentioned in the Outer Space Treaty. As Hanlon pointed out, this concept represents a gap in the treaty insofar as it applies to harvesting resources from other celestial bodies, and it is critical for space faring nations to work together to clarify this concept as the world's space agencies and new space companies set their sights on the Moon and Mars. "Due regard is the only concept that limits the freedom of access, exploration, and use of all celestial bodies," Hanlon said. "It is important for our generation and the next generation to really tease out the understanding of what due regard means because we don't have a legal definition."

Hebe Romero, the General Director of Legal and International Affairs at the Paraguayan Space Agency, spoke about the need for strategic alliances in the development of Paraguay's national space programme. These alliances, said Romero, are important not just for international cooperation, but also for cooperation between the public sector, private sector, and academia. In Paraguay, the stakeholders in the space sector are working together on legislation that helps define the playing field to facilitate these types of cooperative alliances. "The bill we are working on is to establish the processes that regulate the participation of everyone in Paraguay who wish to carry out space activities," Romero said. "Everything is being taken into account."

Daniel Penaherrera, the Senior Lawyer at Abad and Campos Abogados, offered an overview of Ecuador's space policy framework and the history of the country's rights to geostationary orbit. This recognition stems from the 1976 Bogota Declaration, which concluded that geostationary orbit is a limited resource and that countries in the equatorial region must reaffirm their

**“It is important for our generation and the next generation to really tease out the understanding of what due regard means because we don't have a legal definition”**

sovereignty over those spaces. Nevertheless, Penaherrera said, the International Telecommunications Union has not addressed this recognition and is supported in its position by the Space Treaty, which prohibits countries from claiming sovereignty over any object in outer space. While Penaherrera said that Ecuador has ratified almost all international instruments of space law, he said that "it's important for our people to know that we have sovereignty and rights over space like other countries."

Steve Mirmina, a Senior Attorney at NASA's Office of General Counsel, spoke about NASA's origins from a legal perspective to give emerging space nations that may not have a space law some guidance on how to proceed in the absence of pre-existing legislation. In particular, he spoke about the importance of giving fledgling space agencies a lot of autonomy and independent authority, which enables it to create more cooperative agreements with other countries and accelerate its development. Affording a space agency this freedom, said Mirmina, should be considered by countries as they draft space legislation to encourage the development of a domestic space sector.

Joao Paulo Rodrigues Campos, the President and CEO of Visiona Space Technology, offered a perspective on space law from the point of view of the commercial sector. As one of the only non-practicing attorneys on the panel, Campos spoke about how space law has affected his own company's growth and the Brazilian commercial space sector in

general. While Campos acknowledged the importance of stringent regulations for some space activities such as launch services, he also cautioned against having too many laws for more commercial activities such as satellite design. The risk, he said, is that governments risk crushing innovation. "We should support the pioneers and help them navigate these uncharted waters to build their business," Campos said.

Chuen Chern Loo, the Head of Space Publication and Registration Division of the International Telecommunication Union (ITU), talked about the regulation of the radio spectrum as it applies to space activities. Loo spoke about how the ITU is receiving an increasing number of applications from emerging space actors applying for license to operate small satellites and has had to retool its organization to adapt to the changing space environment. He offered a deep dive into how radio regulations are changing and how the industry and member states can participate in those changes.

Marlène Michele Losier, a Principal at Losier Gonzalez, PLLC, highlighted a number of key considerations for spacefaring nations to consider when entering into agreements with other space nations. In particular, Losier spoke about the importance of monitoring normative

legal frameworks, particularly those outlined in the United Nation's Committee on the Peaceful Uses of Outer Space (COPUOS). Losier also emphasized that spacefaring nations must stay on top of norms outside of COPUOS, which have been developed independently by spacefaring nations and new space companies through an ongoing dialogue. Given the complexity and constantly changing legal environment around space activities, Losier concluded that "it is advisable that states consult with experienced space law and policy experts in conjunction with technical experts before entering into broader and narrower or multilateral agreements."

Tatiana Ribeiro Viana, the Scientific Technical Secretary at the Italo-Latin American International Organization, rounded out the session by speaking about the knowledge gaps for emerging space nations in Latin America when it comes to the legal implications of conducting space activities. To help these nations better understand their legal obligations as spacefaring countries, Viana said that she is working with the support of the Italian Space Agency to host a meeting of Latin American States to talk about space law and legally prepare them for their space activities. "We will become stronger and more aware about the importance of space law in conducting space activities," Viana said.



## How to Build a Space Ecosystem

The fourth plenary of GLEC 2022 brought together space thought leaders from government, academia, and industry to discuss how these various sectors do and should interact to create a robust and sustainable space ecosystem.



The panel was moderated by Peter Martinez, the Executive Director of the Secure World Foundation, who opened the session by discussing the various factors involved with connecting these various components and how emerging space nations can think about developing this complex space ecosystem.

The keynote speaker for the session was Valanathan Munsami, the former CEO of South African National Space Agency (SANSA), GLEC 2022 IPC Co-Chair, and Chancellor at International Space University, who started his speech by comparing the space ecosystem to natural ecosystems of plants and animals and identifying the elements that are similar between them. For example, Munsami said, diversity in an ecosystem is an asset. The key is fostering ways for those various elements to interact. At the same time, he said, there must also be clear boundaries between these various elements that define their role in the ecosystem. In terms of creating a space ecosystem that means bringing

together academia, space agencies, and new space firms, but this can get complex very quickly. “So, the first thing you do when building a space ecosystem is put down the space law and policy,” said Munsami. This creates the guidelines that allows all participants to fruitfully interact with one another while also respecting the boundaries between their domains.

Gabriella Arrigo, the Director of International Affairs Directorate at the Italian Space Agency (ASI), spoke about the key policy elements of creating a space ecosystem. Arrigo highlighted four pillars of a sustainable space ecosystem, namely space governance, space policy, space strategy, and space programme. Each of these pillars is useful for defining the ways various players in the space sector interact, what their goals should be through these interactions, the specific steps they will take to achieve those goals, and the actual implementation of those steps through the creation of initiatives and infrastructure.

Greg Autry, a Professor at the Thunderbird School of Global Management at Imperial College London, spoke about how new space entrepreneurship is rapidly changing the way that governments approach creating a space ecosystem. In particular, he highlighted the fact that now these entrepreneurs are dictating space policy by finding new ways of doing things that are not covered in previous policies. As a result, policymakers are falling behind. “We can believe that we’re in a world where clever people in government positions are going to define a policy and a national space strategy, but we’re going to quickly find out we’re trying to keep up,” Autry said.

Michal Brichta, the Head of the Slovak Investment and Trade Development Agency at the Slovak Space Office, offered his perspective on financial and industrial development frameworks for developing a space ecosystem. In Slovakia’s experience, he said, this occurred on both the international level through its participation in the EU’s space program and on the national level, with Slovakia’s own space initiatives. He said that Slovakia started their development by working on the international level within the frameworks established by the EU and the European Space Agency, and then leveraged national tools to accomplish Slovakia’s domestic space goals. “Space is highly internationalized and it doesn’t really make sense to do anything on your own, especially if you’re a small country,” Brichta said.

Guillermo Salvatierra, a Member of Board of Directors at the Comision Nacional de Actividades Especiales, spoke about the most important base infrastructure that should be in place to develop a sustainable space ecosystem. When Argentina started its space programmes 30 years ago, he said, the country did not have much infrastructure. But what it did have was a strong base of human talent and industry. By combining these two components, he said, it was possible to build the infrastructure for a space programme, which led to the creation of a substantial national space industry in a virtuous cycle that has continued to expand Argentina’s space capabilities.

Natavan Hasanova, the Strategic Development and Planning Director at Azercosmos Space Agency of the Republic of Azerbaijan, also spoke about the infrastructure prerequisites to build a space ecosystem. In Azerbaijan, she said, the important thing was to have a strategy informed by a clear vision and goals. With this in place, Azerbaijan was able to assess the resources and capabilities it had

to execute on those goals and make rapid progress in the development of its space ecosystem.

Ian Grosner, a Federal Attorney with the Brazilian Space Agency (AEB), spoke about what can and should be done to create the infrastructure for a robust space ecosystem in Latin America. He highlighted how Latin America already has a lot of history in the space sector that has created the requisite knowledge and talent to continue to develop a space ecosystem. While he acknowledged that there is still a lot of work to be done, he concluded that Latin America is “on the right track,” particularly through its willingness to collaborate with more developed space programmes.



“So, the first thing you do when building a space ecosystem is put down the space law and policy”

## Co-Evolution of the Space Ecosystem

The fifth plenary session of GLEC 2022 featured five heads of space agencies and a representative from the World Space Week Association to discuss the stages of an evolving space ecosystem. The panel focused on the opportunities and challenges that arise after a space ecosystem is created including how to create sustainable governance structures and forge connections between the public and private sectors.

The session began with a video keynote address from Salvador Landeros, the Director General of Agencia Especial Mexicana (AEM), who discussed Mexico's own experience in evolving its space ecosystem. Landeros highlighted the critical importance of the space sector for economic and technological development in Mexico by creating jobs and fostering innovation that improve the lives of its citizens. As an example, Landeros spoke about the importance of Mexico's space-based telecommunications work that both enable its space activities while improving lives of everyday people through agriculture management, improved

communications, climate monitoring, and air observation. Landeros also underscored the role of the private sector in Mexico's burgeoning space ecosystem and how public-private cooperation has both transformed Mexico's domestic economy and made it more competitive in global markets.

Following Landeros' speech, Masami Onoda, the Director of the Washington DC Office for JAXA, set the stage for the panel by outlining the multiple stages of the development of a space ecosystem. Once a country has laid the groundwork for a space ecosystem, she said, it's important for it to create a governance structure that enables further growth by setting ground rules and defining the ways various actors engage with one another. Then, she said, the third state is to start thinking about how to foster private sector participation and how this changes the roles of both public and private space organizations. Finally, she underscored the critical importance of creating programmes to develop talent to allow the ecosystem to continue to flourish in the future.

Natavan Hasanova, the Strategic Development and Planning Director at the Azercosmos Space Agency of the Republic of Azerbaijan, opened the panel by providing a history of the country's space agency since it was established in 2010. She discussed how the country's focus on telecommunications satellites helped it build the technical capacity for space projects while also helping the country generate revenue. Today, she said, 90% of the revenue from Azerbaijan's three telecommunications satellites are being generated outside of the country. Hasanova highlighted the role of these space assets in diversifying the country's revenue while also forging regional connections and fostering international collaborations. Building on this initial success, Azerbaijan's space agency is now working on a National Space Strategy that will help align the country's space activities with its broader national goals along a few key axes: Earth observation, expanding international cooperation, increasing research and development, and sustainable financial growth.

Charles Mwangi, the Director of Space Sector and Technology Development at the Kenya Space Agency (KSA), presented an overview of the evolution of the country's



space sector and the critical role that international cooperation played throughout its history. Mwangi traced the origin of the Kenya Space Agency to interactions with the Italian Space Agency that resulted in creating a satellite tracking station in the country due to its desirable geographic location. At that point, Mwangi said, Kenya did not really have a space ecosystem and it was "not very clear how we would leverage the potential of space in those years." Kenya built on the momentum from this collaboration to establish a National Space Secretariat that eventually grew into a formal space agency that has brought together stakeholders from across the country to develop a policy strategy. Now that the Kenyan Space Agency is in the process of formalizing its governance structure, it is looking to future opportunities such as operating a launch center to leverage the country's equatorial location and expanding its technological capacity through satellite engineering.

Danilo Sakay, the Senior Space Project Analyst at the Brazilian Space Agency (AEB), offered an overview of the Brazilian space ecosystem and how the various stakeholders in this ecosystem such as research institutes, the military, universities, and industry organizations interact and help one another. Sakay discussed how Brazil's space ecosystem emerged from military activity but is in the process of expanding through the public and private sectors as a civil organization. Critical to this development is strong

strategic planning and Sakay discussed many of the programs outlined in its recently completed 10-year plan for national space activities. One of the biggest transitions, Sakay said, was driven by the growth of Brazil's new space sector, which is driving innovation in satellite and launch technologies for the country. An important element of this, he said, is fostering cross-industry collaboration between industries that are very advanced in the country such as mining and agriculture but may not have had much experience with space activities, even if they can be mutually beneficial.

Armengol Torres, the Vice President of Coordination and Education at the World Space Week Association, concluded the panel by discussing the importance of education in the evolution of a space ecosystem. Torres described education as a critical part of the initial phase of creating a space ecosystem because it helps bridge the gap between space applications and their end market or users. In the initial phases of the development of a space ecosystem, it can often be challenging to identify the new possibilities created by space applications for economic or technological development, and Torres said that education can play a critical role in helping stakeholders understand how space applications can help them meet a wide variety of goals. At the same time, a robust educational component will foster the talent that any space ecosystem needs to sustainably grow.

## Space Industry Development and Support

*The sixth plenary of GLEC 2022 featured representatives from eight industry organizations who each offered their perspectives on how to develop and support private sector space initiatives in an evolving space ecosystem. The panel provided diverse perspectives from both new and established commercial space companies that are each taking a unique approach to the future of private space activities.*

The panel began with a keynote address by John Roth, the Vice President of Business Development at Sierra Space, who discussed the growing importance of commercial space activities for the future of the space ecosystem. As Roth highlighted, space activities used to be the sole domain of international space agencies, but the private sector is increasingly taking over many of the traditional roles of space agencies such as launch services, space habitation, and satellite engineering. Roth focused his keynote on the development of a commercial space station that Sierra Space is building in collaboration with Blue Origin. Importantly, Roth said, these new commercial space destinations will provide a unique platform to support the development of commercial space activities ranging from biopharma production and materials research for jurisdictions around the world that may not have had as much access to this kind of space resource in the past. This kind of innovation, he said, is critical to supporting the development of space industries in younger space ecosystems. “There’s an opportunity for all countries to participate in this future and be part of a commercial space economy going forward,” Roth said.

James Causey, the Managing Partner at CWSP International and the Executive Director of the Global Spaceport Alliance, opened the panel with an overview of what he sees as the three key areas for commercial space activity: how to get things into space, what happens when they are in space, and what happens when they return from space. As Causey pointed out, each of these sectors has unique risk profiles, financial investment requirements, and profiles of operating companies. Through his work as the Executive Director of the Global Spaceport Alliance, Causey’s focus has largely been on getting assets into space and getting them back again, which has meant exploring pathways for the development of new spaceports around the world. Given the immense appetite from space participants around the world, Causey said the primary challenge is to make sure that investment in space access is effective and this requires close collaboration between all stakeholders and ongoing dialogues that establish the various goals and capacities of participants.

Vincenzo Giorgio, the Vice President of Institutional Marketing and Sales at Thales Alenia Space Italia and the CEO of ALTEC, discussed how he and his colleagues have

been working to foster cooperation among industrial partners. With all the new entities participating in space, he said, there is “not really one model that works everywhere for every domain.” As such, it is important to think about the development and support of the commercial space industry in the context of the domain where they are seeking collaboration. “The first activity should be a shared goal of the activity that everyone wants to do,” Giorgio said.

Henrik Pettersson, the Vice President of Business Development for Science and Launch Services at the Swedish Space Corporation (SSC), gave an overview of the company and its history of payload development and suborbital flights. Over the course of the Swedish Space Corporation’s history, Pettersson said, it seen a marked change in the way that space activities are conducted. What was once done by national space agencies is increasingly being done fully commercially. Pettersson offered some perspectives on what led to this shift, particularly the declining cost of space access, increased private investment, and a shift in attitude at space agencies from procuring entire products to procuring services. This, said Pettersson, offers an incredible opportunity for emerging space nations because it creates a large pool of potential commercial partners and customers around the world. “It’s kind of leveling the playing field,” Pettersson said. “We see so many new space nations emerging and being able to reap the benefits of more affordable space access.”

Carlos Rodriguez, the COO of Orbital Space Technologies, gave his thoughts on the support and development of

“There’s an opportunity for all countries to participate in this future and be part of a commercial space economy going forward”

industry from the perspective of an emerging space country, where he said that “a lot of things that make sense in other parts of the world don’t really make sense here.” For example, he said, it doesn’t really make sense to try to compete with a company like SpaceX on launch services. Instead, companies in emerging space ecosystems can focus on niche applications that leverage their unique strengths. In Costa Rica, for example, there is a strong base of biologist and biolabs, so it makes a lot of sense to focus on biotechnology applications in space. Most importantly, he said, is sharing success stories from a country, which creates a snowball effect that drives further innovation and inspires more people to build space businesses while attracting financing to support those entrepreneurs. “If you have one success story, everyone starts thinking about it and tries to make their own ideas,” he said.

Luigi Scatteia, a Partner at PwC Space France, offered his perspective as an industry outsider that works with both governments and established industry players as a consultant. From this experience, he said, his organization has been able to draw several conclusions about how to build a sustainable industrial base in a country. One important point, he said, is that there is no single commercial space market, which creates immense amounts of opportunity for emerging players to enter the commercial space sector. Nevertheless, it is critical for those new entrants to realize that commercial space activity does not necessarily translate into commercial demand. Thus, it is important for them to ensure that when they are developing a private space sector that there is enough of a market to support those activities.

Pieter Van Beekhuizen, the Treasurer of the Stichting Space Professionals Foundation and Vice Chair of IAF CLIOND, concluded the panel by talking about how to make the most use of limited funds. Latin American space agencies have only a fraction of the budget of NASA and ESA, Van Beekhuizen said, but this does not necessarily limit their impact. The best way to leverage their limited resources is through collaborations with other agencies and focusing on applications that leverage their existing capabilities. In Latin America, for example, Earth Observation applications can play a big role in supporting the development of a space industry, particularly through the analysis of the data provided by remote sensing platforms. This can not only provide a natural stimulus for economic growth, but also help meet pressing national challenges such as natural resource management, emergency response, or even organized crime detection. “I believe that in order to have the support for a region like this it is very important that the possibilities for these new technologies that are made available with Earth observation data is used to the maximum extent,” Van Beekhuizen said. At the same time, he called upon established space actors to invite emerging space economies into the fold and support them in ways that will allow them to make the most use of this data.



## Benefits of a Space Ecosystem Approach

*The final plenary of GLEC 2022 brought together industry leaders and the heads of national space agencies to discuss the benefits of a space ecosystem approach. The speakers offered their perspective on the opportunities and challenges for collaboration between the public and private sectors based on their own experience and the lessons these experiences hold for the future of emerging space ecosystems.*

Robert Aillon, the CEO of Leviathan Space Industry, initiated the session with a keynote address that examined the immense economic benefits of a space ecosystem approach. Aillon spoke about how he is focused on a goal of working with spaceports, which is an important subject because they can fill many different roles such as horizontal or vertical launch, a center for productions or research, a center for testing, or a center for education. The multidimensionality of a spaceport is analogous to the multidimensionality of a space ecosystem writ large. The key is to make connections between various local and international partners, leverage the unique capacities of a given region or country, and plug the ecosystem into even larger networks. Aillon offered an overview of what that looks like for Ecuador in particular, including the importance of the space sector for domestic non-space industries like agriculture, education, and tourism.

Following the keynote, Alejandro Roman Molinas, the General Director of Aerospace Development at the Paraguayan Space Agency, set the stage for the panel by discussing the multitude of benefits that a space ecosystem approach can bring to emerging space economies. “There are a significant number of emerging countries that have not grasped these important benefits and how they can assist the social economic development of the country yet,” Molinas said. “A healthy and strong space ecosystem is a process that needs many components and actors.” The goal

of the panel, he said, is to offer a variety of perspectives that would show how a space ecosystem approach can drive scientific, technological, industrial, commercial and social development in emerging space nations.

The first speaker on the panel was Fuad Aslanov, the Vice Chairman of Azercosmos Space Agency of the Republic of Azerbaijan, who told the story of the development of a space ecosystem in Azerbaijan. The country’s space activities began in 2010 with a Presidential decree to become a satellite operator, which was met with general skepticism. “Many people were questioning the idea—why does such a small country need a satellite operator?” Aslanov said. Yet after the successful launch of Azerbaijan’s first satellite in 2013, the doubts started to fade and the country focused on developing an internal market for space activities such as telecommunications and remote sensing. This required communicating the benefits of these programmes to various government ministries and showing how space assets could help with everything from agriculture to mining. As a result of these efforts, it resulted in broad support for more space activities and the formal establishment of a national space agency last year. “This shows us that having a space ecosystem is very beneficial for the country and its economy,” Aslanov said. “And nowadays it’s more possible and realistic than it used to be.”

Rodrigo Leonardi, the Coordenador de Satelites e Aplicacoes at the Brazilian Space Agency, discussed the



various building blocks that are part of a space ecosystem and how they must work together to accomplish national goals in the context of engineering a Brazilian satellite. For example, the development of Amazonia-1, Brazil’s first Earth observation satellite, required creating the infrastructure to integrate the satellite components, which requires interacting with industry and assembling stakeholders who can provide the required subsystems. At the same time, this satellite project also helped bring young engineers into the fold and develop a base of talent that can contribute to more space projects in the future as a result of their training and education. Furthermore, since the satellite was launching on an Indian rocket, it required fostering international collaboration and establishing governance frameworks for this kind of collaboration. “Every time you do a project, it is a vehicle through the space ecosystem and how you’re going to interact with it, maybe even influence and improve it,” Leonardi said. “Some of these projects are very complex and some are very simple, but all of us are involved in projects on a routine basis.”

Pilar Zamora Acevedo, the Executive Director of the Colombian Space Agency, spoke about space technology for emerging countries based on her experience in Colombia. Colombia’s space agency was born four years ago with an intention to focus on space applications for agriculture and national resources. As part of its mandate, the Colombian Space Agency is working closely with local communities to expand access to STEM education and lay a foundation for a domestic space economy by helping young people learn about satellite engineering. The important thing is connecting the role that these space technologies can play for advancing non-space initiatives such as protecting natural resources, which creates support from industry, government, and the Colombian public. “We have the necessities for space technology,” Acevedo said. “We have great natural resources, a workforce of young professionals, and a theory of what we can do from an economic perspective.”

Petr Bares, the Honorary President of the Czech Space Alliance, discussed some lessons learned from the Czech Republic’s participation in the European Space Agency.

Bares spoke about how the Czech Republic’s role in ESA has grown substantially over the past decade-and-a-half from a modest 1 million Euro budget to around 60 million Euros as the country developed its space capacity. “One of the important factors in how we managed to grow so quickly is the fact that we became members of a large international community, which gave us wider opportunities, participation in bigger programs, and help from countries and individual companies during our initial process of learning the ropes,” said Bares. Another key contribution to the Czech Republic’s success was the development of an association to support academics, and industry players, as well as influence government decisions around space activities, which has helped dramatically expand the country’s space industry as well as its role in the broader European space ecosystem.

Maria Cristina Falvella, the General Inspector of the Italian Space Agency and President of Fondazione Amaldi, offered some perspectives from Italy’s 60-year history in the space ecosystem. According to Falvella, one of the most important development occurred in the last two decades as the space sector has undergone a rapid transition through commercialization. To help address these changes, the Italian Space Agency established the Fondazione Amaldi with the goal of supporting an applied research focus to transfer technology and maximize the impact of investments made in space. The result of this investment in applied space research and technology transfer speaks for itself. Today, Falvella said, Italy has around 200 companies that cover all aspects of the space value chain and the Foundation has supported more than 400 high-tech developers that work with dozens of research and academic institutions to develop new innovative technologies. The lesson from this, said Falvella, is that a sustainable space ecosystem needs more than just investment, it also needs policies that support those investments. “You can have the best technology in the world, but if this technology cannot target the needs of the community and is not able to build up local capacity, it will never receive endorsement at a wider level,” Falvella said. “This is a model that can be replicated to increase the role of private stakeholders for commercial exploitation.” ■



Tuesday  
17 May 2022



# GLEC 2022

## IAF Global Networking Forum (IAF GNF)



### Latin American And Caribbean Space Agency (Alce)

*The Convention establishing the Latin American and Caribbean Space Agency (ALCE) was signed on 18 September 2021 in Mexico City by 18 countries from Latin America and Caribbean, marking both a turning point and an opportunity to foster cooperation and space activities in the region. Today, the number of signatories has reached 22 countries. At GLEC 2022, we had the immense pleasure and honour to welcome distinguished representatives from Mexico, Ecuador, Peru, Paraguay and Argentina who discussed the set of ambitious goals set by ALCE and emphasized the role of socioeconomic return of investments in space science and technology as a clear rationale that spurred the launch of the regional space agency.*

Latin America has the advantage of being a pioneer for conceptualizing the analytical framework of technological capabilities. Thanks to its flourishing entrepreneurial environment and unique socio-economic factors, the region offers a large path for growth to the space industry and local players. With a plethora of space projects in the public-private commercial coalition and ground communication facilities, ALCE aims to contribute significantly to achieving the objectives of strengthened coordination in terms of exploration, research, space technology and related applications in order to benefit the Latin American and Caribbean communities. The panel outlined the regional perspectives on the overall dynamics in the space sector, specifically regarding capabilities in Earth observation systems, meteorology, oceanography, exploration of natural resources, urban intelligence, security and surveillance and also, pointed out the models and key measures that will help ensure sustainable and productive space activities both at national and regional level. Signatories are well aware of their synergies at the regional level with strong pillars linked to the private sector and capacity-building. The success of ALCE depends now strongly on a coherent vision and a cooperative and aligned approach to guarantee that the regional challenges are properly addressed such as the lack of adequate financial resources and financial incentives to expand services, lack of a coherent legal framework, or lack of trained personnel to operate space-crafts and to interpret data from remote sensing satellites. The relevance of coordinated efforts will be felt at cross-sectoral levels, just as this will further avoid duplication of efforts when it comes to regional space activities.



“ALCE’s mission is to provide regional mechanisms for cooperation, collaboration and to enable the exchange of experiences in Latin American countries for the exploration of outer space with pacific purpose”



Wednesday  
18 May 2022

**Governance Risk And Compliance In The Emerging Space Ecosystem**

*This IAF Global Networking Forum Session outlined how space entities can build a transparent, sustainable and resilient space ecosystem. Space organizations, whether they are public or private, see Governance, Risk and Compliance (GRC) as a vital process that not only defines their ecosystem but also shapes the roadmaps for future opportunities and growth.*

The implementation of the GRC processes has been a real journey for some institutions such as the Brazilian Space Agency, for which it took three years to find a consensus and even required to amend the legal framework. Much of the success relies in the approach of these institutions into promoting space benefits among all the stakeholders, but also highlighting the interconnectedness of risks. On the commercial side, it is essential that entities embrace an integrated approach to make them stand out in terms of competition and sustainability. The emerging space nations need to demonstrate flexibility and resilience to deal with a multitude of entities internationally and show a long-term and inclusive vision when shaping their national and regional policies, from encouraging innovation, industry, economic growth and infrastructure. While corruption may hinder these efforts in some regions, the institutional factors such as the reinforcement of reforms and preventive actions shall protect the integrity and effectiveness of the space ecosystem.



“It is important to share the view of developing countries in developing space capabilities, it is a matter of transparent and confidence building and intensifying our international relations and control space activities”

**Developing A Space Exploration Ecosystem Based On International Collaboration**

*The future depends on the power of collaboration and the global space exploration ecosystem. The speakers recommended that all stakeholders shall seize the potential of space exploration to grow the workforces needed today and build those that will be key in the future, as they will grab the revolutionary opportunities that offer global cooperation. The global space community shall be also committed to ensure ecosystem sustainability and expand the diversity of people in the field.*

Pascale Ehrenfreund, the President of the International Astronautical Federation (IAF), highlighted that the IAF is a pioneer example of accomplishing this vital mission through ISEP, known as the IAF Space Economic Platform – Bringing Space Down to Earth/Bringing Earth Up to Space. Bernard Foing pointed out the importance of cooperative instruments and robotics, how building systematic resiliency is key to preserve security and safety of operations and space infrastructure for missions to Moon and Mars. Marchel Holle and Carlos Mariscal shared the same opinion that we need to balance investments to enable innovation, entrepreneurship and opportunities for emerging space nations. Based on the Kenyan experience, Charles Mwangi stated that it is now clear that space technology is accessible to everyone and has broken barriers across nations. Gustavo A. Cabrera Rodriguez emphasized that we need to improve education, prepare a talented and committed workforce, to help regional entities such as ALCE embrace the rapid change of technology and ensure sustainability of the space ecosystem. Anthony Tsougranis promoted the need for a safe and transparent environment, based on interoperability and mutual trust which are essential for operations in space and on Earth.

“NASA is engaged in many projects and international collaboration is part of including the NASA’s Artemis Programme. The programme is an inspiration for a new generation of explored: The Artemis Generation, and will engage many countries as well as many companies”



The Gender Gap

“I believe it is a very good moment for woman to have careers in space. I believe the success stories of women played a role of a game changer and we have now more girls who want to have a carrier in STEM”

An inclusive space ecosystem is critical for ensuring that equal opportunities are provided to everyone. Gender disparities in the space sector is a fact and an inconvenient truth, and remains connected to cross-cutting right-based issues. The number of women entering the space workforce is progressively changing, this trend is more promising since more women join STEM studies and space careers. As space is pushing for more equality, governments must ensure that woman’s empowerment and gender equality are prioritized and addressed. It is important to lift

mental barriers such as the dream gap and showing young girls that their potential is not limited. Many institutions start showing their commitment to gender equality by establishing family friendly policies and facilitating women’s careers. While there is inadequate access to education and technology and even unsupportive work environments, institutions shall make progress regarding outreach to enhance gender balance, workforce diversity and equal opportunities for all.



Thursday  
19 May 2022

Space In Schools & The Role Of Academia

*Space is considered as the absolute of inspiration for STEM education. It is the most powerful and interdisciplinary environment that triggers the potential of the future workforce and initiates the most successful collaborative projects. As STEM careers in space are expected to grow exponentially in the next decade, it has become urgent for educators, schools, academia but also for space leaders to keep up with the future demand for STEM leaders in the workforce, not only to teach and learn, build trust and inspire the next generation.*

Science and education popularization is considered crucial for the sake of the development of society. With collaboration, co-working, and best practices and resources being exchanged between institutions worldwide, we will provide equal access to scientific knowledge and skills, trigger more interest and build the space workforce of tomorrow. Many programmes such as Once Voice 4 Change, M2P or Switch to Space give practical recommendations for high-school teachers and teacher education programmes to increase the academic performance in STEM domains and grow a qualified and diversified workforce in space that will help design a future for the regions. Since the sector is facing new dynamics and a rapid pace of change, institutions have also a vital role to play in attracting diverse group of students to STEM through learning opportunities and hands-on experiences that spark passion and provide connection to space missions and work.



“From the perspective of One Voice 4 Change, the answer is to collaborate. Collaboration instead of competition is key in order to increase the interest in STEM subjects in schools. Students have passions, and we need to start listening to them, then you become unstoppable forces. I hope we will take action on this today”

## Space Technology For Emerging Countries

Growing access to space creates a variety of opportunities. The emergence of new space technologies is astonishing and becomes an important driver for development and innovation in emerging countries. In the context of the sustainable development goals, countries explore continuously the potential of space data, science and applications to achieve the Sustainable Development Goals (SDGs). These tools benefit countries at various income levels regardless of whether they have a space programme or an established space agency. The role of regional and international collaboration efforts supports the spillover effects in many areas such creating new opportunities for innovation and infrastructure. The speakers highlighted successful programmes and projects that can help promote harnessing space technologies. Masami Onoda made reference to the IAF CLIODN committee which has been a long-standing committee collaborating with UNOOSA through the IAF by holding the annual UN/IAF Workshop. The achievement of the SDG is intrinsically linked to the successful use of space technology and the availability of high-quality data accessible for all. The significance of outreach and space awareness has been reminded during the GLEC discussion on space technology. Speakers agreed that part of the outreach strategy requires developing an understanding of the rationale and development paths of all space actors, particularly emerging ones. Danilo Sakay mentioned that there is a vital need for long-term political support as the space activities of emerging space nations are more vulnerable. The need to keep up with the rapid pace and tendencies of the space ecosystem is a challenge added to the risks of compliance on space sustainability issues. These factors must be taken into account when engaging emerging space nations into a broader ecosystem, as they will help them define the needs for their specific space programmes and be fully integrated within the global space architecture.

“It is necessary to strengthen for the civil protection of the population of our regions, especially with regard to the increase if the frequency and intensity of hurricanes; within the framework of the launch of the Goes-T satellite in Mexico, we will strengthen the current space education agenda in the country with emphasis on protecting population from disasters”



## Latin American Culture In Space

*The last session of GLEC 2022 depicted the intrinsic relation between space projects and indigenous culture in Latin-America and outlined the societal repercussions and cultural significance of space in the region. A plethora of indigenous and cultural practices are based on the relational view of space, the understanding of our origins, and how our collective future depends on space.*

Katherine Herrera Jordan recalled that “the first space culture in Guatemala were the Mayans, whose lives evolved around astronomy”. From an anthropological point of view, art projects can be viewed as a tool for education, promotion and democratization of space. Indeed, emerging space countries have managed to create a significant constellation of social actors who work in conjunction with the space industry including students, scientists, academicians, lawyers, politicians, artists as well as anthropologists, and planetarium and observatory designers. The panelists showcased the

incredible diversity and richness of the Latin-American culture in space and how it impacted the scientific knowledge. Today, it is critical that the industry plans for outer space must be built with humankind as a whole, including the protection of astronomy practices essential to the way of life of many indigenous peoples. Space culture can be considered as a contribution towards greater sustainability in the approaches currently being taken towards space activities. Experts also believe that we are on the right track to inspire and shape the next generations of archaeologists and space artists. ■



“Culture expresses in numerous ways; art is the one with identify it the most, through literature, images, sculpture. Culture also extends to many other activities as it influences our perceptions of the world through our interactions with it. Culture is embedded in almost everything human including our perception and relation with space”

# GLEC 2022

## Space Law and Policy Masterclass

*The Space Law and Policy Masterclass was a one day event hosted on the first day of GLEC 2022 that featured panels on topics related to establishing space ecosystems, space governance in emerging countries, and raising awareness for policies that foster innovation in the space sector. The masterclass consisted of a roundtable discussion followed by a two-part workshop and panel discussion, and featured policymakers, heads of agencies, and business leaders from around the world.*

The masterclass began with some words of welcome from Sergio Marchisio, Full Professor of International Law at Sapienza University of Rome, who was the Master of Ceremony and moderator for each session. As Marchisio remarked at the start of the sessions, the goal of the masterclass was to raise awareness of the “essential legislative and policy elements that must be considered in establishing a firmer foundation for a national regional space programme.” Since the tenets of international space law were well known by most of the masterclass participants, the sessions focused largely on elements of national and regional space law and policy and how these elements interact with the international space law and policy frameworks.

### Summary: Roundtable

The first roundtable of the masterclass was focused on “addressing the legal and policy elements for establishing space ecosystems in emerging countries,” and featured

speakers two space agencies, an NGO, and an international regulatory agency. The first speaker was Gabriella Arrigo, the Director of the International Affairs Directorate at the Italian Space Agency (ASI), who summarized the main policy elements that serve to build a space ecosystem. Arrigo used examples from several national space programmes in the US, Russia, China, and Europe to demonstrate various approaches to creating national space doctrines and how these national space policies interact with one another on the global level.

Arrigo was followed by Peter Martinez, the Executive Director of the Secure World Foundation, who began his talk by comparing space policy to a map. “Maps depict the world as we understand it and I want to use that same analogy for how we develop space policy because sometimes there are hidden assumptions that we incorporate into the way we develop national policy,” said Martinez. He gave an overview of the current space sector and made the case that space policy is “never developed in a vacuum,” but sits at the intersection of several other national and international goals and strategies, which it must take into consideration.

Steve Mirmina, a Senior Attorney at NASA’s Office of the General Counsel, offered some remarks on the importance of national space laws in the context of international agreements and gave an overview of how international space treaties are handled in the US. He concluded his talk by sketching out pathways for countries to collaborate with one another and how these collaborations can guide the creation of national space policy. These points were expanded upon by Marlene Michele Losier, a Principal at Losier Gonzalez, who provided a general overview of key considerations related to multilateral and bilateral space agreements. Losier acknowledged that while broad multilateral agreements such as the UN Outer Space Treaty are critical for ensuring the peaceful use of space, they are slow and difficult to create, which has led to a proliferation of more narrow international space agreements that are still in accordance with larger multilateral agreements.



The first session of the masterclass concluded with a talk by Chuen Chern Loo, the Head of Space Publication and Registration Division at the Radiocommunication Bureau of the International Telecommunications Union (ITU), who provided a high-level overview of how the ITU works with national space programmes to regulate bandwidth. The role of the ITU in fostering collaboration among space nations is critical, Loo said, because “radio frequencies and orbits are limited natural resources and they have to be used rationally, efficiently, and economically, and that’s the objective of radio regulations.”

### Summary: Workshop PT. 1

The first workshop of the masterclass was devoted to “sharing experiences and practices on space governance and law in emerging countries” and featured representatives from several emerging space agencies. The first speaker of the workshop was Tatiana Ribeiro Viana, the Scientific Technical Secretary at the Italo-Latin American International Organization (IILA), who described the IILA’s work as a consultancy working in space law and diplomacy. Viana was followed by Daniel Penaherrera, a Senior Lawyer at Abad & Campos Abogados, who described the current state of space law in Ecuador. In particular, Penaherrera spoke about the legal status of geostationary orbit as enshrined in the Bogota Declaration of 1976 and the tension between this piece of policy and fundamental principles outlined in the UN’s Outer Space Treaty.

Charles Mwangi, the Director of Space Sector and Technology Development at the Kenya Space Agency (KSA), gave an overview of the origins of the agency in its collaboration with Italy and how it has evolved over the past few decades. Mwangi spoke about the importance of evolving from a national space secretariat within the Kenyan government to a formal space agency, which better positioned the country to support space innovation. Mwangi was followed by Hebe Romero, the General Director of Legal and International Affairs at the Paraguayan Space Agency, who gave a history of the agency’s evolution and its current objectives. Ludovica Ciarravano, a Research Fellow in Space Law at Sapienza University of Rome, concluded the first part of the workshop by discussing the benefits that can be derived from space governance mechanisms. In particular, she highlighted their importance for regional cooperation, which is an important lever for fostering national space development for emerging nations.

### Summary: Workshop PT. 2

The second part of the masterclass workshop was focused on “sharing experiences and practices on space governance and law in emerging countries” and featured the expertise of several legal experts from across the world. The first speaker was Carolina Catani, a Technical and Legal Responsible in Space Law at the Commission Nacional de Actividades Espaciales, who spoke about Argentina’s experience crafting a space governance platform. In particular, Catani discussed the nation’s experience transitioning from a space programme that was largely led



by the defense sector to one that was led by a civilian space agency, which forced Argentina to focus on its institutional organization capacity and how its space programme would be organized and managed to achieve its policy goals.

Following Catani was Ian Grosner, a Federal Attorney at the Brazilian Space Agency (AEB), who offered his perspective on Brazil's experience with crafting space governance. Grosner noted that Brazil is likely the only nation to address space law in its national constitution, but despite this emphasis on the importance of space governance there are still a number of gaps in its national space law pertaining to basic guidelines for space activities. These are crucial, Grosner said, for fostering agreements with other nations and developing its national space capabilities.

Melanie Majuma Munyori, a Legal Officer at the Kenya Space Agency (KSA), provided the masterclass audience with a history of Kenya's space programme and offered a rationale for its creation. She highlighted the social benefits, institutional need, and industry support that a dedicated space agency was able to bring to the country, which was critical for helping Kenya achieve its objectives in space and expand its national space sector. Munyori also offered her take on six steps for achieving a legal framework for space that was used by Kenya to establish its space agency and how these lessons from Kenya's experience might be applied in other emerging space nations.

The final speaker at the workshop was Gianfranco Gabriele Nucera, a Researcher in International Space Law at Sapienza University of Rome, who spoke about the role and definition of partnerships in the context of international cooperation on space activities. Nucera underscored the critical importance of strong legal frameworks for fostering international cooperation, and pointed to the historic relationship between Italy and Kenya as an example of a strong partnership that was enabled by established legal frameworks in Italy. But perhaps the most important element of a successful international partnership, said Nucera, is a willingness to share capacity and knowledge with your partners.

### Summary: Panel

The Space Law and Policy Masterclass concluded with a panel discussion on the topic of "how to better create



awareness of the need for legislation and policies to drive space economies and foster innovation," which included perspectives from several experts in industry and academia. Michelle Hanlon, the Co-Director of the Center for Air and Space Law at the University of Mississippi, was the first speaker and she focused on current gaps in space law and how they might be bridged. One of the many examples offered by Hanlon was the tension between the freedom of access and use of outer space with the necessity for restrictions that ensure that one spacefaring nation does not accidentally or intentionally undermine the capacity of another nation. This, said Hanlon, calls for deep thinking about how to create restraints on space activities without undermining the freedom of space operations enshrined in the UN Outer Space Treaty. "We have a real opportunity to bring the entire world with us into the next set of negotiations as we work to fill the gaps in international space law," Hanlon said.

Joao Paulo Rodrigues Campos, the President and CEO of Visiona Space Technology, was the only non-legal expert on the panel and he offered his perspective on how space legislation and policies impacts companies working in the space sector. Campos drew on his experience as a space entrepreneur in Brazil as an example and underscored the importance of ensuring that laws are clear and comprehensive, and that processes for engaging with regulators are streamlined. One of the best ways to do this, said Campos, was to build on existing laws rather than creating entirely new laws. Ultimately, however, Campos said the best way to raise awareness for the need for better laws and policies is to highlight the successes of a national space industry to show how improved policies can unlock still more successes.

Pierfrancesco Breccia, a Post Doctoral Fellow in International Space Law at Sapienza University of Rome, spoke about the fundamental importance of government funding for the development of a national space industry. As Breccia pointed out, conventional equity investment models are poorly suited for starting a space industry in an emerging economy. Instead, these space entrepreneurs must be supported by government funding and participate in regional partnerships, which will have the cumulative effect of attracting more space investments to the country and establishing a robust national space economy.

The final speaker for the masterclass was Anne-Sophie Martin, a Post Doctoral Fellow in International Space Law at Sapienza University of Rome, who focused on how space legislation can be used as a tool to enhance the development of space ecosystems in emerging countries. As part of her talk, Martin compared and contrasted the experience of two African spacefaring countries: South Africa and Nigeria. The experience of these countries, Martin said, provides an opportunity to understand how certain governance and policy decisions—such as joining an international space treaty before founding a national space agency—can influence the evolution of emerging space nations. ■

# GLEC 2022

## The Space Industry and Entrepreneurship Workshop

*The Space Industry and Entrepreneurship workshop brought together young and experienced entrepreneurs, space agency representatives, and policymakers to discuss how to foster space entrepreneurship and innovation in emerging space nations. The workshop included two keynotes, an interactive workshop and demo of a new cloud-based ground station platform, and two panels focusing on investment, entrepreneurship, and the opportunity for new space in Latin America.*



The workshop began with opening remarks from Matias Campos, the CEO and Founder of Astralintu Space Technologies and the workshop moderator. Campos began with a story about his childhood in Ecuador and his dream of participating in space exploration, which set him on a path toward space entrepreneurship. As Campos recalled, his dream of wanting to participate in the space economy as a Latin American was easily dismissed when he was younger. "Traditional space was not something for us," Campos said. "But something is changing in Latin America. Now with new space we can bring the benefits of space to our society."

Campos was followed by Renato Panesi, the Chief Commercial Officer at D-Orbit, who provided the sponsor welcome address for attendees. Panesi recounted his journey to space entrepreneurship and highlighted the important role that a developed entrepreneurial ecosystem

in Silicon Valley played in the creation of D-Orbit. This, said Panesi, highlighted the important role that all actors in a space ecosystem have to play in fostering innovation in space, which requires more than just investment. It needs to fundamentally be a holistic approach to supporting space entrepreneurship. "When talking about space in emerging countries, we need to create the whole infrastructure and ecosystem that makes it possible," said Panesi.

### Interactive Workshop

The interactive workshop was led by Bruno Carvalho, the Director of D-Orbit Portugal, who gave an overview of the past, present, and future of distributed mission operations of satellite fleets. Carvalho focused in particular on the development of Aurora, a system built by D-Orbit that provides "ground station as a service." As Carvalho recounted, Aurora began when D-Orbit had trouble sourcing

mission control software from established vendors that quoted them millions of dollars to operate their CubeSat. This was well beyond the budget of D-Orbit, so instead the company set out to build its own ground station software.

The first test for Aurora was for D-Orbit's first CubeSat, which required the team to use and maintain a lot of expensive servers and hardware. They realized that this would be infeasible as they prepared to build out a fleet of satellites in orbit, so instead Carvalho and his colleagues came up with a simplified solution: Rather than running the servers and other associated ground station hardware themselves, they would outsource this work to cloud service providers. The result was Aurora, which can be run from any internet connected device and used to manage a single satellite or an entire fleet.

During the interactive workshop, Carvalho provided a live demonstration of Aurora collecting information from one of D-Orbit's satellites as it made a pass over the UK. Carvalho also discussed the future of cloud-based services for space data, which he said would move toward a "space edge-computing cloud." In this arrangement, satellites would be able to data to each other in space and process it on board, which would help relieve congestion in space to ground communications while also increasing access to actionable space data. "The most important thing is to have information we can act on as a community," said Carvalho. He hoped that space edge computing will be the right solution for realizing this promise.

## First Keynote

The first keynote of the workshop was given by Clay Mowry, the Chief Revenue Officer at Voyager Space Holdings. Mowry offered an overview of his journey as an entrepreneur in the space sector, starting with his work in government through his career at Blue Origin and most recently at Voyager Space Holdings. With over 25 years of experience in the sector, Mowry offered a broad perspective on how the new space industry has changed, particularly in the past few years, which he argued has made space entrepreneurship more accessible than ever before.

"At the beginning of my career there were many of these stories about successful entrepreneurs because space was dominated by larger companies and space agencies,"

Mowry said. "What you see now is a very, very dynamic environment."

One of the biggest hurdles to the burgeoning new space ecosystem that Mowry identified is access to the large amount of capital entrepreneurs need to get their businesses off the ground. Space is by its nature a very capital intensive industry, but the confluence of more affordable technologies such as CubeSats, and the infusion of private capital into the industry has laid the foundation for an unprecedented expansion of new space companies over the next decade. "It's an exciting time for the space industry," Mowry said. "We're living in an era where entrepreneurs can actually build an idea into something with not the kind of incredible amounts of capital it used to take."

## First Panel

The first panel of the workshop provided a high-level overview of investment and entrepreneurship in the space sector. It was moderated by Valanathan Munsami, the Former CEO of South African National Space Agency (SANSA), GLEC 2022 IPC Co-Chair, and Chancellor of International Space University (ISU), who opened the session with some examples of how South Africa's space agency fostered space entrepreneurship in the country. One of the most important initiatives undertaken by the agency, Munsami said, was to establish an industry forum to increase engagement between the public and private space sectors. This led not just to more engagement with industry, but also a number of related initiatives such as the recently launched New Frontiers fund that provides grants to industry applicants. At the same time, the space companies in South Africa stepped up to sponsor innovation prizes and events to further spur the development of a national new space economy.

Michal Brichta, the Head of Slovak Investment and Trade Development Agency at the Slovak Space Office, also offered his perspective on how the space agency achieved tremendous results in increasing space entrepreneurship in the country. When the Slovak Space Agency began working with trade and investments in 2019, it faced two main challenges: First the national space ecosystem was small and second there was low international awareness of the capabilities in Slovakia. To overcome this problem,



the Slovak Space Agency focused on increasing the number of companies in the country while simultaneously helping those investors attract outside support. As a result of its initiatives, which included government funding as well as innovation events such as hackathons, the number of new space companies has doubled to more than 40 in just 3 short years.

Elzbieta Jablonska, an Entrepreneur, Mentor, Advisor, and Executive Coach with deep experience in the new space industry, offered her perspective on how to improve the connection between governments and startups. One of the most important things from an entrepreneur's perspective, said Jablonska, is balancing their passion with consistency. At the same time, entrepreneurs need to be prepared for the many challenges they will face in the space sector, which requires a willingness to be patient, to learn, and to pivot to new opportunities when necessary.

Joerg Kreisel, the CEO at JKIC, offered some remarks on how ecosystems are the next big things in space and the role that entrepreneurs will play in these ecosystems. By drawing comparisons with natural ecosystems, Kreisel made the case that it is important to understand how the multitude of different subsectors in the space ecosystem fit together so that stakeholders can deploy their resources more effectively. Kreisel also acknowledged the challenges with equity financing in the space sector given that it is predicated on a return to investors, which is a substantial departure from the more technological and programmatic focus of government space agencies in the past.

The final speaker of the panel was Rentao Panesi, the Chief Commercial Officer at D-Orbit, who described his unconventional path to building a space startup from seed to a forthcoming public offering. Panesi remarked on how drastically the space ecosystem has changed in the past decade, which made it significantly harder to raise capital when he was just starting out. "12 years ago, no one was talking about the space economy," said Panesi. "The mindset of investors at the time was really different. I remember pitching our ideas to them and we seemed like aliens to these investors."

## Keynote 2

The second keynote of the entrepreneurship and industry workshop was given by Joerg Kreisel, the CEO at JKIC, who spoke on the subject of "the myth, reality, and outlook" as space as a playground for entrepreneurs. One of the major themes of Kreisel's talk is that there is not just one way to be a space entrepreneur. "Space entrepreneurship is not really straight forward, there are many areas that the entrepreneur could approach," Kreisel said. While this is a good thing in the sense that it provides entrepreneurs with many opportunities, it also means that entrepreneurs must be incredibly aware of how their business fits into the wider space ecosystem.

This is particularly important for entrepreneurs in emerging space countries, said Kreisel. The reason is because the strongest pathway toward building a space ecosystem in these nations is not by trying to do everything. Instead, entrepreneurs in these countries should find a niche and use that to grow their national and regional space capacity. But in order to do this, those entrepreneurs must understand the market dynamics of their niche, the case for investing in that niche, and the technological challenges associated with pursuing that pathway. Kreisel backed up his point with a high level overview of the development of the commercial space sector from the telecom boom of the 1970s to the birth of commercial human spaceflight over the past two decades. "The question for both space entrepreneurs and space agencies is: Where do you want to play?" Kreisel said.

While no one can know for certain what the future holds, Kreisel urged budding entrepreneurs in emerging space countries to look at the emerging problems that space can help solve. Issues like water, food, and resource scarcity can benefit a lot from space-based assets, and these are potent areas to explore building a business. In the concluding remarks of his keynote, Kreisel also offered an overview of the tradeoffs of various kinds of capital available to space entrepreneurs ranging from government funding to equity debt. Ultimately, he said, the right choice for an entrepreneur will depend on what they are actually building. "If we design things and operate things in



different ways, then we'll have an evolution of business models," Kreisel said.

## Second Panel

The second and final panel of the workshop featured entrepreneurs from across Latin America who spoke about their experiences building businesses and the challenges still faced by entrepreneurs. Daniela Mera, the Vice President and Marketing Director at the Sideralis Foundation, moderated the conversation and highlighted how inspiring it was to see so many young entrepreneurs in attendance at the workshop. "This panel really summarizes the 3Gs we are looking for at this conference," she said.

Victor Baptista, the Chief Operating Officer at Idea Space, opened the panel by speaking about his experience as an entrepreneur in Brazil and how his company worked with academics and other businesses to bring space education into the classroom. His business accomplishes this with "pocket cubes" that can be built by students and sent to space, which he hopes will help lead more young people into the Brazilian space sector in the future.

Moses Browne Mwakyanjala, the Founder and CEO of Remos Space Systems and the only non-Latin American on the panel, described his experience of spinning out Remos from his PhD project in Sweden. Mwakyanjala's company focuses on satellite operations and has, in particular, developed systems based around software-defined radio, which dramatically lowers the cost of satellite ground operations. This, he said, is critically important for lowering the capital cost of space projects and making them accessible for new space companies in emerging space economies.

Matias Campos, the CEO and Founder of Astralintu Space Technologies, gave an overview of his company's work on helping other companies integrate and deploy payloads. In the past, Campos said, "Latin American countries have not been part of this." But now, he said, there is an incredible opportunity in new space for entrepreneurs and the private sector to build a robust space sector in their individual countries and across Latin America. While Campos acknowledged that there was still a significant lack of investment capital in the region, he also underscored

how Latin American space entrepreneurs could make up for the lack of financial capital with an abundance of human capital in the region.

Katherinne Herrera Jordan, the President and Co-Founder of the Guatemalan Association of Space Sciences and Engineering, gave an overview of her company Verne Technologies, which had only launched a few months prior to the workshop. Jordan recounted her journey to entrepreneurship, which began with her struggle to find an affordable way to conduct microgravity experiments on Earth. Together with a friend, she developed a customizable machine that could be used to do affordable simulated microgravity experiments and began to see a huge demand for the machine from students across the country. In response to this demand, Jordan launched Verne and is now helping researchers throughout Guatemala engage with space research.

Carlos Mariscal, the CEO of Dereum Labs, described his experience in helping non-space industries do R&D in space. "We all know that space is not sustainable without the help of non-space related industries," Mariscal said. "But the thing is these startups usually don't know how to do the necessary activities in space." Dereum Labs was created to help bridge this gap and help companies launch space missions. Still, Mariscal said that one of the biggest challenges remains simply convincing companies why space is important to their business. By engaging with these businesses in non-space industries, Mariscal hopes to see greater engagement with the space sector from a wide variety of nominally non-space companies.

Jose Medina Bosleman, the Founder and Director of Space Latam, described the role of the social enterprise in developing the space industry across the Latin American region. To accomplish this, Space Latam focuses on three core areas: entrepreneurship and innovation; space data for society; and formalizing cooperative networks. Each of these, said Bosleman, is a critical part of the foundation that allows space entrepreneurs across Latin America to thrive.

Carlos Rodriguez, the Chief Operating Officer at Orbital Space Technologies, was the final speaker of the panel and the entrepreneurship workshop. He described how he managed to create a company in Costa Rica despite there being no existing infrastructure to support the development of a space company. The key, said Rodriguez, was identifying broader social problems—such as the extinction of key agricultural crops like bananas—and making the case to policymakers and investors about how space assets could help solve these problems and save the country potentially billions of dollars. Still, Rodriguez lacked the capital to bring his ideas to life, but he managed to win an international innovation contest for space entrepreneurs. This allowed him to establish his company and extend hardware for space experiments to other researchers and entrepreneurs in emerging space nations, and demonstrates the virtuous cycle of space entrepreneurship on a national and global scale. ■



# GLEC 2022

## Ministers And Members of Parliaments Forum



*The Ministers and Members of Parliaments Forum was a special session of GLEC 2022 that brought together policymakers and heads of industry together to discuss strategies for improving public and private sector collaboration to support emerging space ecosystems.*

The session was co-chaired by Dominique Tilmans, the President of EURISY, and Sheldon Lopez, the Undersecretary of Telecommunications and Postal Affairs at the Ministry of Telecommunications and the Information Society, who each offered some opening remarks before giving the floor to their esteemed panelists.

Klaus-Peter Willsch, the Chairperson of the Aerospace Group at Deutscher Bundestag, opened the session by discussing the impact of Germany's recent elections on space policy and how the German government is supporting the nation's space ambitions. Willsch noted how the German government is in the process of developing a new space strategy to update their most recent strategy released in 2010. One of the most important pillars of this new strategy is using space assets to counter climate change, while also exploring exciting new opportunities such as sending a German astronaut to the Moon. Willsch

also highlighted the importance of working with partners in South America on Earth sensing activities as well as forging connections with industry to drive those initiatives forward.

Zeynep Yildiz, a Member of National Education, Culture, Youth and Sports Commission in Turkey, discussed the importance of cooperation for the future of space activities. After giving a short history of Turkey's participation in space, Yildiz outlined the 10 targets of Turkey's national space programme, which includes a Moon programme and a Turkish astronaut programme. While Turkey already has five satellites in space, the country is focused on expanding its industrial capacity for space technologies and expanding its research capabilities. Yildiz also underscored the importance of the Outer Space Treaty in guiding Turkey's national space programme, particularly its emphasis on the free exploration without discrimination of any kind.





“Its basis in equality is the key to our principles regarding space,” Yildiz said. In particular, this guiding framework is why Turkey is emphasizing cooperation in its space activities and believes that a “fairer world is possible.”

Raivo Tamm, a Member of Parliament, Riigikogu, Republic of Estonia, spoke about the plans, experiences and challenges for the future of space in Estonia. While the country has participated in the development of space technologies and equipment since the 1960s, it became a more active participant in the industry over the last 15 years. In 2013, the country launched its first cube satellite and became a full member of ESA in 2015. One of the most exciting recent developments, said Tamm, is the development of the Estonian Space Act, which will soon be presented to the country’s parliament. This act will help increase public investment in the sector and expand its participation in ESA programmes, which is in line with Estonia’s vision of increasing its opportunities to collaborate and invest in the space industry. “To fulfill the potential of our industry and live up to our ambitions, cooperation between international organizations is crucial in the future,” said Tamm.

Gustavo Cabrera Rodriguez, the Mexican Ambassador to the Latin American and Caribbean Space Agency, concluded the panel with a call for investing more in the development of local space industries. To underscore his point, Rodriguez told a story about how a state in central Mexico that had a very traditional economy focused on textiles and agriculture, became a hub for the country’s automotive and aeronautical industries through government investment during the middle of the 20<sup>th</sup> century. He spoke about how government initiatives helped create Aeronautical University and a number of training programmes and workshops to teach workers the skills they needed to participate in the new economy. The key lesson here, said Rodriguez, is that emerging space nations must invest in educating and supporting their workers to give them the skills they need to participate in the new space economy. “The rule used to be build it and they will come, but the new rule needs to be teach it and they will come,” Rodriguez said. “We need to invest in our people.” ■



# GLEC 2022

## Closing Ceremony

*GLEC 2022 wrapped up with a closing ceremony that highlighted the diversity of attendees, the importance of international collaboration, and an invitation to GLOC 2023 in Oslo, Norway to focus on the role of Earth observation and remote sensing for addressing some of Earth’s most pressing climate challenges.*

Pascale Ehrenfreund, President of the International Astronautical Federation (IAF), initiated the closing ceremony with some remarks about the importance of a space ecosystem for building a space economy. With its astonishing diversity of participants—from government leaders to heads of industry, academics to technologists—GLEC 2022 demonstrated just how important it is to connect the multitude of stakeholders in the space sector to build a sustainable future. Ehrenfreund also remarked on the importance of the diversity of participants in the space sector as well. At GLEC, roughly 50% of the participants were below the age of 35 and more than one-third of the participants were women, an incredible success that demonstrates the space sector’s commitment to inclusion and diversity.

Juan Jaramillo Rojas, the President of the Sideralis Foundation, expressed what a great achievement it was to bring so many people from around the world together to foster the development of emerging space nations. In particular, he highlighted how the conference underscored that “the Latin American community is ready to participate and be an active part of the space community.” The exchange of hard-won lessons and knowledge during

GLEC 2022 gave rise to many new ideas and projects that will make the global space ecosystem stronger than ever in the future.

Valanathan Munsami, the Former CEO of South African National Space Agency (SANSA), GLEC 2022 IPC Co-Chair, and Chancellor at International Space University (ISU), said that he thought the conference achieved its primary objective by having more than 200 participants representing 42 countries in attendance, a remarkable feat especially given the challenges presented by the global pandemic. “I think we are starting to make new history,” Munsami said. “We are setting a new agenda and pushing the boundaries in terms of an emerging country focus.” Munsami also highlighted how the conference represented a success for the IAF’s “3G” Diversity Principles as evidenced by the diversity of geography, gender, and generation at the conference.

The final speaker of the closing ceremony was Christian Hauglie-Hanssen, the Director General of the Norwegian Space Agency (NOSA), who offered a few reflections on the week-long conference. In addition to the new friends made during GLEC 2022, Hauglie-Hanssen drew attention to the incredible ambition on display from the attendees. In particular, he underscored the importance of space activities such as remote sensing and Earth observation for dealing with some of the world’s toughest challenges such as climate change, which he announced would be the subject of GLOC 2023 in Oslo, Norway. ■

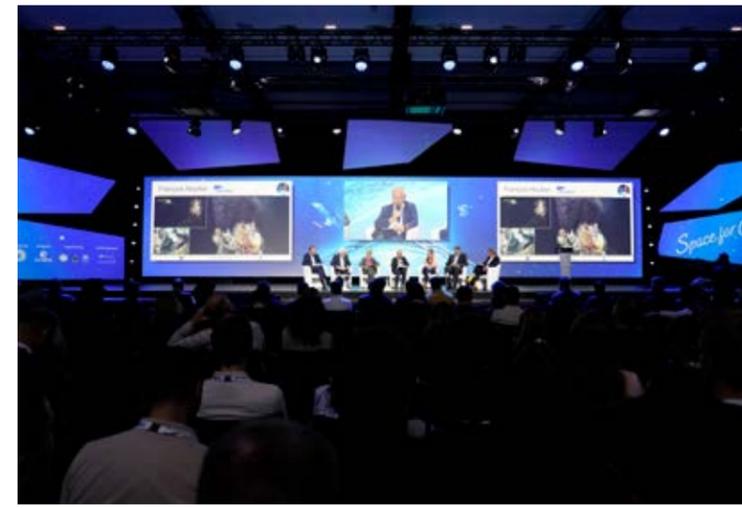
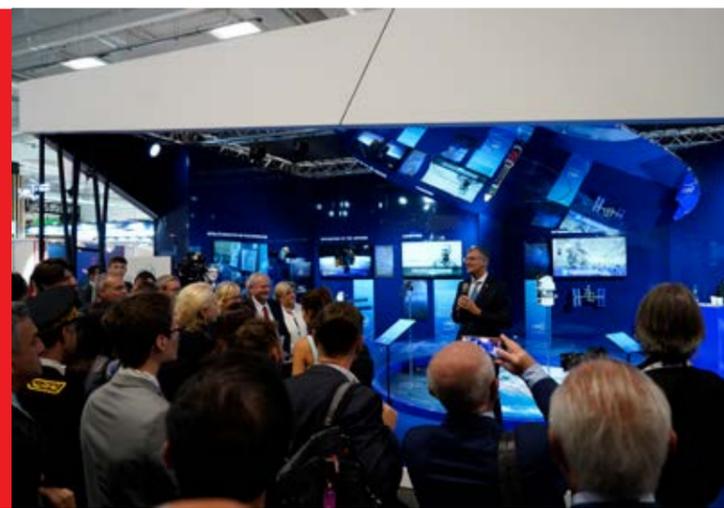


“We are setting a new agenda and pushing the boundaries in terms of an emerging country focus”



# International Astronautical Congress

18 - 22 September | Paris, France



# IAC 2022

## Opening Ceremony

IAC 2022 kicked off with an Opening Ceremony featuring high-level speeches, entertainment and finished with an IAF Award Ceremony. Two ministers from France addressed the IAC audience, French Prime Minister, Élisabeth Borne, and Valérie Pécresse, President of the regional council of Île-de-France. Borne announced in her speech the fantastic news that a budget of 9 billion Euros has been assigned to the French space sector over next three years. Pascale Ehrenfreund, President of the

International Astronautical Federation (IAF), said “We are welcoming more than 8,700 registrants from 110 countries. We have over 3,000 presentations and almost 250 exhibitors. This IAC 2022 is breaking all records!”. Philippe Baptiste, President of the Centre National d’Études Spatiales (CNES), also welcomed the audience to the 73<sup>rd</sup> International Astronautical Congress to his hometown Paris. ■





IAC 2022

Plenaries



## Heads of Agencies

Moderated by IAF President Pascale Ehrenfreund and IAF Executive Director Christian Feichtinger, the opening plenary explored the Congress' theme of "Space for @ll", with space agency heads outlining current projects and future priorities.

Ehrenfreund stressed the need for national agencies to cooperate in a time of profound challenge and change, before Philippe Baptiste, President of the Centre National d'Etudes Spatiales (CNES), said the four pillars of France's space programme ensure independent access to space, promote scientific excellence, boost economic competitiveness and promote diversity. He urged international agencies to strike the right balance between strategic independence and collaboration to tackle global challenges in partnership with a dynamic private ecosystem.

of Earth, underlining the importance of our planet even as we reach for the stars.

Josef Aschbacher, Director General of the European Space Agency (ESA), said its members had delivered on their pledge "to bring the benefits of space and its applications to citizens in Europe and worldwide" in 1975 and now have 540 international agreements. ESA has four main launch programmes, including the European Service Module for Artemis 1, and recently received 23,000 applications from would-be astronauts, proving the enthusiasm of young Europeans. The Jupiter Icy Moons Explorer (JUICE) mission in 2023 will explore Ganymede, Europa and Calisto for potential signs of life, while the Euclid spacecraft will hunt for dark matter, and the Copernicus constellation will proliferate.



National Aeronautics and Space Administration (NASA) Administrator Bill Nelson said NASA now collaborates with many international partners, in contrast to the Apollo programme. The European Service Module will soon fly on the new Artemis launcher, and many countries will contribute to the return to the Moon and exploration of Mars. NASA also partners with SpaceX and Boeing, and 15 nations operate on the International Space Station (ISS). NASA has worked with the Russian Federation since 1975, although relations are now strained by the invasion of Ukraine.

“Space will become more crucial than ever in helping humanity face the global challenges that lie ahead”



The James Webb Space telescope is opening a new age of interstellar astronomy, and Double Asteroid Redirection Test (DART) aims to alter an asteroid's course, while orbital observation paints a detailed picture of man's degradation

February's Toulouse Space Summit saw European Union (EU) and ESA delegates discuss priorities, and November's Ministerial Conference will discuss issues arising from current geopolitical turmoil. While economic problems threaten space spending, investment is more important than ever to strengthen communication and navigation infrastructure, and safeguard security. An independent, resilient and stronger European presence in space is vital to the future of all Europeans.

Lisa Campbell, President of the Canadian Space Agency (CSA), said Canada's three RADARSATs take 250,000 images every day, and CSA is boosting its ability to track worsening wildfires and monitor change in oceans and inland waters. CSA helps firms develop new products and applications using space data and scale their offerings to global size. The agency aims to attract young people to science, retain the brightest talent and make Canada the home of strong, competitive and successful space businesses.

Hiroshi Yamakawa, President of the Japan Aerospace Exploration Agency (JAXA), said JAXA will design life support systems for the proposed Lunar Gateway space station, build a pressurized rover to hunt for ice at the lunar south pole and send Japanese astronauts to the Moon by 2030. Launched in 2014, JAXA's Hayabusa2 probe returned regolith samples from Asteroid 162173 Ryugu in 2020 and will now intercept Asteroid 1998 KY26 in 2031. JAXA aims to launch its Martian Moons eXploration (MMX) mission to the Martian moons in 2024 and return regolith samples from Phobos in 2029. Japan also operates Earth observation satellites, and Mitsubishi Heavy Industries' H3 rocket should deliver flexible, reliable and low-cost launch capacity in 2024.



Sreedhara Somanath, Chairman of the Indian Space Research Organisation (ISRO), outlined ISRO's plans to create a new commercial arm and encourage Indian start-ups to build a domestic space sector. ISRO supports space-based services in weather forecasting, navigation and communication, and its plans for the 2023 Chandrayaan-3 Moon lander and 2025 Chandrayaan-4 Lunar Polar Exploration mission are moving ahead.

Bill Nelson called for international agreements to ensure the interoperability of manned space operations and protect the peaceful use of space for all mankind. Speakers looked forward to a permanently crewed Moon base, a more diverse space community, greater investment and stronger partnerships to ensure the economic and scientific potential of the space sector is fully realized.



## Space4all: Space For all the Inhabitants of Planet Earth

Moderator Gilles Rabin, Advisor to the President of CNES, argued that space, like the Earth, belongs to all humanity and so the benefits of space infrastructure, data and services must improve the lives of everyone.

François Houiller, President of the French Research Institute for Exploitation of the Sea, explained its role in monitoring ocean fishery and energy resources, protecting and restoring the marine environment and sharing scientific data with stakeholders worldwide.

Oceans cover 70% of our planet and play a key role in global water cycles. They absorb 90% of the heat produced by global warming and 30% of the carbon we emit, while producing almost 20% of consumed protein. Oceans are polluted by chemicals, choked by plastic and denuded by overfishing, but only 20% of the sea floor has been mapped and just 240,000 marine species of at least a million have been identified.

Space and the deep ocean pose similar challenges to human exploration, but comparable strategies deploying intelligent robots, remote sensors and manned capsules increase knowledge all the time. Orbital observation of

marine conditions, security threats and rising seas has proved invaluable, and inform the fight against climate change.

Conny Hansel, a PhD student in urban design, outlined the importance of spatial data in city planning and comprehending the 'pulse' of urban life in terms of transport, logistics, weather and public space. Millions of individual routines coincide in rush hours and choke points, which data-based planning can ease to improve efficiency and quality of life. Global populations are increasingly urbanized, so building liveable, navigable and sustainable cities is paramount. Satellites can map tree cover, urban sprawl and heat islands, inform agile traffic management and improve citizens' lives.

Stefan May, French Head of Continental, said his company based itself in Toulouse to use the technological expertise of the French aerospace industry. Over 100 million vehicles are manufactured every year, all of which need tyres, electronics and other automotive equipment. Modern cars have complex software packages, with more lines of code than fighter planes, and use satellite services for global positioning system (GPS) and breakdown alerts. Innovations in electric and autonomous vehicles will



“Our challenge is to turn space research into practical outcomes on Earth and build a better future for all humanity”



boost demand for ubiquitous connectivity, and increased satellite tracking will optimize journey planning, regulate traffic flows, and impose highway and city tolls to reduce congestion.

Rafaela Kraus, Vice President of the Universität der Bundeswehr München, explained the University's close relationship with the German armed forces and its mission to support Germany's technological and military sovereignty. Ukraine's fight against foreign invasion highlights the value of agile, innovative strategies against conventional forces, and many graduates launch their own firms after their military careers.



Space technology has found innumerable terrestrial applications and synergies in other realms. Innovation tends to blossom in new, rather than established, firms, and the University's accelerators help start-ups from across Europe expand into sustainable companies in industry, agriculture and technology.

Genethon CEO Frédéric Revah recalled his father's pioneering space research in the 1970s, before explaining his company's focus on gene therapy and biomedicine. Gene splicing could potentially cure thousands of genetic diseases afflicting 350 million people worldwide, most of them children, half of which prove fatal.



Despite initial doubts concerning its practicality, modified viruses now splice therapeutic DNA into human cells to cure these conditions, though manufacturing complexity means the cost remains high. The first successful gene therapy, for immunocompromised 'bubble babies,' saved hundreds of lives, and thousands of children with spinal muscular atrophy and other neuromuscular conditions can now be treated. Manufacturing these products in microgravity could reduce costs and increase availability, with similar techniques potentially easing the muscle atrophy suffered by long-duration astronauts.

Nicolas Gaume, CEO of Space Cargo Unlimited, expressed confidence that individual passion can change the world, and science and technology forge a better path for mankind. His companies translate scientific research into commercial products and could produce perfect alloys and purer medicines in microgravity.



Space Cargo is tackling the agricultural challenges of climate change by breeding heat and drought resilient crops, as nature needs a helping hand to survive rapid anthropogenic warming. Experiments on ISS produced vine strains which thrived back on Earth, funded by sales of wine aged on the space station.

## The Value of Low Earth Orbit in the Next Decade

Dan Dumbacher, Executive Director of the American Institute of Aeronautics and Astronautics (AIAA), introduced the plenary discussion on current value and future developments in low Earth orbit (LEO) up to 2030. NASA has announced ISS will operate another eight years, for example, while Europe, India and China are developing their own capabilities alongside a multitude of commercial players.

Mary Lynne Dittmar of Axiom Space, contracted in 2020 to provide a new \$140 million commercial habitat for ISS, recalled her long involvement with the station and praised its capacity to accrete new capabilities over time. It has hosted ground-breaking research and taught humans how to live in space, spurring increasing interest in research and manufacturing in LEO.

Robyn Gatens, NASA's ISS Director, said the platform currently hosts seven astronauts, who are regularly resupplied and rotated. Astronauts from 20 nations have visited ISS, and 109 nations have been involved to some degree, increasing global interest in space and cultural diversity in terms of problem solving. Zimbabwe and Uganda will add to that tally when their CubeSats are flown there on an upcoming mission.

A decade of ISS research is bearing commercial fruit, and 60% of the ISS National Laboratory's time is now taken by private companies. Investors are flocking to the commercial space sector, and private LEO platforms designed and built by Axiom, Blue Origin, Nanoracks and Northrop Grumman could replace ISS by the end of the decade.

Iwao Igarashi, Vice President of Mitsubishi Heavy Industries, said his company manufactures launch rockets, cargo modules and experiments for space, including a centrifugal gravity generator in constant demand. He called for increased human presence as well as robotic work in LEO to inspire public interest.

“We're at the cusp of a new era, transitioning from government run platforms to commercial space stations and industries in low Earth orbit”

Shawna Pandya, a Scientist-Astronaut Candidate from the International Institute for Astronautical Sciences (IIAS), promised a brave new age of LEO activities. Exciting opportunities to pursue medical research and manufacture semi-conductors, alloys and pharmaceuticals in microgravity are developing, while LEO also offers a comparatively safe and accessible testbed for exploration missions to the Moon, Mars and beyond.





Japan has also seen a surge of interest in travelling to and working in space, with more than 4,000 people applying to its latest astronaut recruitment scheme, and firms gain reputational credit as well as practical outcomes from their involvement.

Artemis and the return to the Moon will spark another wave of public enthusiasm, and coming years will see more commercial products flow from current research, encouraging more firms and government agencies to explore their space options. A whole-of-government approach and strong private interest should see LEO manufacturing 'take off' to create new markets in medicines, lenses, polymers and other advanced and exotic materials.

International agreements to train astronauts and build engineering capacity in more countries are being made, space business-to-business relationships are being formed, and new types of partnerships will evolve to utilise multi-use modules hosting a flexible range of experimental and manufacturing activities.

Humans will soon have scientific, engineering and operational jobs in orbit, and new rules mandating interoperable parts and shared standards on new stations should foster

cooperation and safety. Although a space economy is yet to emerge, terrestrial economies benefit hugely from orbital data and services and should reinvest in new LEO capacity. More international spacefaring firms may also emerge to challenge SpaceX, Boeing and Blue Origin, as new research, assembly, manufacturing and repair opportunities appear in LEO, and NASA becomes a customer, rather than provider, of LEO platforms.

Efforts to encourage STEM education and gender and cultural diversity in science and the space sector should increase access for women and minorities. Dozens of nations now have their own space agencies, and individuals with non-engineering skills will increasingly find suitable careers within the sector.

A robust international framework of fair, transparent and equitable rules should ensure responsible and mutually compatible development of diverse LEO capabilities, as the cost, risk and complexity of launches decline and life support systems improve to make LEO increasingly accessible to everyone. While problems such as space debris remain, a combination of human ingenuity and market forces should herald a bright future for LEO activities in the next decade.



## AI4Space: Perspective from the Next Generation



“If we want to protect the bravest of us, those astronauts who are going further from home than any of us have ever dreamed, we will need intelligent and adaptive non-human collaborators”

Artificial Intelligence (AI) allows machines to autonomously perform tasks which previously required human intelligence or intervention. It has numerous applications in space, from data analysis and mission design to ground operations and deep space exploration. The sector is already embracing its potential, with semi-autonomous rovers roaming Mars, and swarms of flying robots may soon dock and refuel ships in space without human intervention.

Assistant Professor Danielle Wood of Massachusetts Institute of Technology introduced Luke Heffernan of the

Australian Institute for Machine Learning who observed that humanity's pioneers to other worlds are invariably robots rather than people. Succeeding human explorers will initially depend on increasingly intelligent machines until they become partners, rather than tools.

Audrey Berquand, ESA Research Fellow, explained her ambition to extract relevant information from voluminous project documentation using natural language processing (NLP). NLP helps computers comprehend the nuances of human language and can search sprawling datasets in seconds to produce requested details, although this



AI has numerous everyday applications on Earth, from data processing to automated engineering, which could be transferred into space. Orbital observation platforms generate terabytes of information, for example, and AI processing of this data on board would reduce the size of data transfers. However, AI-empowered components and craft must be thoroughly evaluated in space conditions, given the difficulty of retrieving, repairing or replacing machines on distant missions.

AI should improve access to space for smaller nations and start-up companies by reducing costs and mission reliance on highly trained astronauts and large support teams. The speed with which Ingenuity, NASA's Martian helicopter, was developed shows the potential for cheaper, faster AI-driven designs.

The mix of robots and people in future space activities will depend on the task at hand, but collaboration between artificial and human intelligence will always be required. While humans still excel at handling unpredictable events, advances in uncertainty quantification will build trust in remote space operations beyond direct control. However, overreliance may become danger in itself, as people lose the ability to perform tasks taken on by machines. Understanding how algorithms work, and their potential to generate error, will be safer than trusting them implicitly, and the extent to which satellite constellations, for example, are controlled by machines requires a human calculation of risk and reward.

AI will reduce the problem of communication latency in deep space by automating routine operations, but people should still control life-imperilling decisions. Systems which perform flawlessly in the lab can be degraded by harsh space conditions, and any temptation to overuse it in planning and operations should be resisted. AI designers which merely iterate on previous machines will not replace human creativity when leaps of imagination are required.

Robots will not inspire the next generation to explore the galaxy, and the human factor in space exploration should never be forgotten. AI should expand, rather than contract, human achievement and possibility, rather than become an end in itself.



requires stakeholders to release the relevant information regarding space designs.

Kelsey Doerksen, a PhD student at Oxford University, elaborated on ways AI can extract useful information from enormous datasets to inform designs and mission planning. AI can also use orbital data to improve landslide predictions in Nepal as well as exclude noise to map the cosmic microwave background.

Antonio Stark, CEO of the Unmanned Exploration Laboratory, outlined its work on rovers in this new age of lunar exploration. Future Lunar and Martian habitats will need intelligent robotic systems for life support, launches and communication, and automated rovers will use smart algorithms to optimize their limited resources while completing challenging tasks. NLP and sentiment analysis could also empower onboard AI assistants for astronauts on space missions.

Sorina Lupu, a PhD student at Caltech's aerospace and robotics lab, envisioned numerous AI robots performing a full range of construction, communication and exploration tasks on the Moon and Mars. AI will reduce mission costs and improve outcomes, as reinforcement algorithms allow machines to navigate uncertainty and 'learn on the job,' leaving humans free for higher level activities while protecting their safety.

## New horizons for Earth observation: Adapting our Societies to the Impacts of Climate Change

Climate change has become an existential challenge to mankind, but copious data from Earth observation satellites have failed to prompt effective international action to reduce emissions and tackle rising temperatures.

Laurence Monnoyer-Smith, Head of Sustainable Development at CNES, urged greater global effort to turn accumulated knowledge and real-time data from space into practical action on the ground.

Fortunately, the French-initiated Space Climate Observatory is coordinating international efforts to produce tools for climate monitoring, mitigation and adaptation. Founded in 2019, it brings scientists, governments and businesses together and supports 60 projects, from weather disaster management to environmental monitoring.

Arnaud Andre, Co-Founder of la Société Générale d'Evaluation des Territoires (SGEvT), detailed one of these projects: a public-private partnership to mitigate severe flooding in a vulnerable French locality by fusing Copernicus data with local information. This tool highlights at-risk areas and is available online to help local farmers and landowners improve agricultural resilience and prepare for future heavy rain events.

Amal Layachi, Head of Capacity Building Department at the Centre Royal de Télédétection Spatiale, discussed another project to support sustainable irrigation in Morocco, a developing nation threatened by drought and desertification. Additional projects to monitor water resources, optimize agricultural practices and protect natural habitat will be designed with local stakeholders, universities and agencies to advance Morocco's national water strategy.

“Climate knowledge and action must rely on accurate and readily available information. Satellite data offers near real time monitoring of our planet and can translate into insightful tools for decision makers and citizens”



With the help of the EU, a range of other programmes in Africa now monitor its terrestrial and marine environment to safeguard food security, protect natural water systems and inform risk management for climate-related disasters.

Rosa Maria Ramirez De Arellano Y Haro, Head of International Affairs at Agencia Espacial Mexicana (AEM), explained the numerous agreements Mexico has signed with international partners to combat climate change and improve disaster management. She called for a collective global effort from governments, agencies, companies and individuals to honour the Paris Agreement, collaborate on effective mitigation measures and share data to meet sustainable development goals.

Stéphane Mermoz, a CESBIO researcher and founder of GlobEO, said that forests still cover almost a third of Earth's land surface, but warned that precious tropical forests containing half the world's biodiversity are being cleared at an alarming rate.



The Tropos NGO project uses satellite radar data to produce detailed maps of remaining rainforest cover in Gabon, French Guyana, Suriname, Guyana, Vietnam, Laos and Cambodia, which are available online with a host of accompanying data. Additional maps covering the Amazon, Congo and Southeast Asia will soon highlight the pressing need to prevent illegal logging and mining, control fires and agricultural clearing, and eliminate the endangered wildlife trade.

Simonetta Cheli, ESA Director of Earth Observation Programmes, said ESA has integrated a host of data from space missions and terrestrial sources to build a better picture of climate change since 2008. Over 450 scientists now work with ESA's Climate Change Initiative and use space observation data to track climate variables, rising sea levels and deforestation around the globe.

Satellite data will inform effective coastline protection from rising seas, warn urban heat islands in ever-hotter summers, and offer localized as well as globalized predictions of current threats and future trends. This data should be freely shared to build capacity in developing countries,

with measures developed in wealthier nations adapted for local circumstances elsewhere.

Shereen Zorba, Head of Secretariat at the UN Science-Policy-Business Forum on the Environment, explained how satellite-generated environmental data already informs international and governmental decision making. While a vast amount of information is available, more can always be used, but it must promote effective, evidence-based solutions on the ground to have an impact.

The patchy implementation of multilateral agreements to reduce carbon emissions has failed to keep pace with the growing climate emergency. However, the success of the 1987 Montreal Protocol in phasing out damaging fluorocarbons to protect the ozone layer show that rapid and radical global action can be agreed and undertaken to solve environmental problems identified from space. Orbital observation data must drive more effective, evidence-based action by governments, companies and individuals to protect current and future generations from the consequences of the past as part of global anti-climate change efforts.

## Defending Earth: The International Effort to Protect Us from Asteroids and Comets

Asteroids, meteorites and cosmic debris have battered our planet for billions of years. The dinosaurs disappeared after the Chicxulub impact 66 million years ago, and our Moon was created by a planet-sized collision early in Earth's history. An enormous impact today could precipitate tsunamis, firestorms or an 'impact winter', while a direct hit by a 100-meter body could devastate a city or region. International partners and agencies are therefore building awareness and developing technology to protect Earth from catastrophe.

Diverting a rogue asteroid with a "kinetic impactor" is one option for defense. NASA's DART will hit the 160 metre Dimorphos Asteroid on 26 September 2022 to alter its orbit as a proof of concept. ESA's Hera mission will visit Didymos/Dimorphos in 2026 with multiple instruments to assess the impact site. These missions will shape the design of planetary defence craft should the need ever arise.

Dipak Srinivasan of Johns Hopkins University said mid-size Near Earth Objects (NEO) pose the major threat, as the orbits of larger asteroids are known, and smaller objects disintegrate in the atmosphere. Less than 0.4% of the 20 metres+ asteroids in the solar system have been identified, and any impact from asteroids 50 meters to a few hundred metres across could have devastating results.

NASA's Bhavya Lal said the United States' Office of Science and Technology Policy developed a Near Earth Object Preparedness Strategy and Action Plan in 2018 to detect, analyse and deflect hazardous objects, encourage agency and international cooperation and plan for potential disaster.

The 20-metre meteorite which exploded over Chelyabinsk in 2013 was not spotted on approach, but the International Asteroid Warning Network is building a better NEO



“It's fun to go looking for asteroids, and doing so might save the world”



database, with the NEOWISE space telescope proving particularly productive. A future infrared NEO surveyor, positioned at L1, 1.5 million km inside Earth's orbit, should further slash the time required to detect most asteroids over 140 metres.

Richard Moissl, ESA's Head of Planetary Defence, explained his agency's efforts to identify and track NEOs, and plan for potential impacts. Images of new bodies from telescopes around the world are analysed to calculate their orbits, in collaboration with other agencies, and close fly-bys are flagged for attention. Bespoke telescopes are being designed to find smaller objects approaching Earth, and ESA plans an automated warning system for decision makers and disaster agencies. The 350-meter Apophis Asteroid will skim past Earth on April 13, 2029, visible to the Northern naked eye, underlining the importance of these projects.

Betsy Congdon, Lead Mechanical Engineer on the DART mission, said that 550-kilo craft aimed to hit Dimorphos at 6.1 km a second, guided by an on-board camera, transferring momentum, and ejecting material to change its orbit around its 780-metre partner Didymos.

Hera Mission Principal Investigator Patrick Michel said asteroids were a fascinating area of study, as they date from the early solar system and could be mined for metals and minerals. A range of exploratory missions have

been undertaken and are planned to understand their extensive history, complex composition and surprising diversity, as well as defend against them. Data from the Hayabusa2 and OSIRIS REX missions suggest that some asteroids are loose conglomerations of dust and rubble, rather than solid objects, but others are compacted rock or metallic.

Bill Nye, CEO of The Planetary Society, outlined its public education efforts and the contribution of amateur astronomers to NEO observation and the Sentry Risk Table, not least on June 30<sup>th</sup>'s 'Asteroid Day' which commemorates the forest-flattening Tunguska airburst in 1908.

Panellists agreed that navigating government bureaucracy, securing funding and driving international cooperation were as challenging as the science and engineering involved in detecting and deflecting NEOs. Educating the public about the asteroid threat should avert a *Don't Look Up* scenario, and preparing better detection and deflection methods today should stand the world in good stead tomorrow. A major impact in our lifetimes is a low probability but high consequence event, but having happened in the past, they are inevitable in the future. The larger the potential impactor, the sooner it may be discovered, but the more difficult and time-consuming it will be to target and deflect, and the more serious the consequences of failure.



## James Webb Space Telescope: The Story of International Collaboration and a New Era of Astronomy for All

“If we want to protect the bravest of us, those astronauts who are going further from home than any of us have ever dreamed, we will need intelligent and adaptive non-human collaborators”



### Part I: Mission Challenges

The \$10 billion, 6 metric ton James Webb Space Telescope (JWST) is the sector's most ambitious project since ISS. An international collaboration involving hundreds of scientists and thousands of engineers in the United States, Canada and Europe, this high-resolution infrared instrument, stationed in solar orbit 1.5 million km from Earth, should transform our comprehension of cosmic evolution.

Moderator Steve Bochinger, COO of Euroconsult, introduced executives and engineers to explain the programme's challenges and 30-year gestation, before scientists shared some preliminary results.

NASA's Thomas Zurbuchen said it had taken three national space agencies, 14 nations' experts and a suite of aerospace companies to turn their vision into reality. Forging the teamwork required among such diverse stakeholders was not easy, and the launch itself was challenging, given the

size and complexity of the precious payload, but the JWST's success has justified their years of toil.

CSA President Lisa Campbell said her country contributed the fine guidance sensor which guarantees JWST accuracy to a millionth of a degree, while its Canadian-made Near Infrared Imager and Spectrograph can detect everything from water in an exoplanet's atmosphere to some of the earliest and most distant galaxies. Canadian scientists will use 5% of the telescope's time, giving young astronomers the chance to make ground-breaking discoveries.

Josef Aschbacher, ESA Director General, outlined ESA's contribution of JWST instruments and the work of European scientists to analyse their results. The project's success has galvanized global interest in astronomy, and its potential to solve cosmic mysteries will be realized over many years to come.

Stéphane Israël, CEO of Arianespace, said strict construction protocols and ever closer international collaboration had



produced the JWST's successful launch by an Ariane 5 on Christmas Day 2021, despite taking 35 times the work of a standard take-off due to the size and complexity of the telescope and its remote destination at Sun-Earth L2. This gravity-balanced position keeps the JWST stable and in line with Earth for constant communication and protection from the sun.

**Part 2: Mission Results**

Eric P. Smith, a JWST Scientist at NASA, said the telescope will explore every phase of cosmic history with an 18-part, 6.5 metre mirror collecting a hundred times more light than the Hubble. Its multi-wavelength sensors can penetrate galactic dust to image areas hidden from human view. The telescope's spectacular vistas of early galaxies, hot pre-supernova 'wolf' stars, star-forming nebulae and stunning spiral galaxies have already grabbed public attention.

Pascal Tremblin, a Researcher at CEA Paris-Saclay, said thousands of exoplanets were detected by NASA's Kepler mission, but the JWST's additional spectrometers allow exoplanet atmospheres to be analysed. The JWST has already found carbon dioxide on one gas giant, orbiting close to a sun-like star 700 light years away. Although smaller, rocky planets in their stars' habitable zone are more difficult to detect, potentially life-bearing planets with atmospheric water and oxygen could be discovered.

Vassilis Charmandaris, a Physics Professor at the University of Crete, acknowledged the international partners who accomplished this complex and colossal task, before sharing infrared images of interacting galaxies previously shrouded by dust in deep space. Peer-reviewed requests from scientists around the world will determine which areas to image in the future, and many more discoveries will be made.

The furthest galaxies in our ancient, expanding universe can only be seen in the infrared, but the JWST gives scientists the data they need to calculate their age and distance. A staggering variety of spiral, elliptical and merging galaxies, some with supermassive black holes, are being observed, many in huge galactic clusters. Gravitational lensing by nearby galaxies allows the JWST to glimpse galaxies just 400 million years after the Big Bang, and further analysis across a range of wavelengths should offer clues to the universe's formation.

Science is a global endeavour, and so scientists around the world are analysing and sharing Webb data – although timing communal calls across time zones can be difficult. By 2050, mankind may have found signs of life on habitable worlds, proving the power of technology, concerted international endeavour and the scientific method to advance humanity's understanding of our universe. ■



**IAC 2022**

Highlight Lectures



## Extreme Exploration: Parker Solar Probe and Solar Orbiter trailblazing Around the Sun

Jason Kalirai, of Johns Hopkins University's Applied Physics Laboratory, introduced the lecture on two extraordinary probes currently conducting 'extreme exploration' of the Sun. Every star in the night sky is a colossal ball of hydrogen producing vast amounts of energy, and life on our own planet depends on our own Sun. Despite its importance, many questions have remained about its nature, and dispatching these probes will help answer them.

Nour Raouafi, a Parker Solar Probe Project Scientist at Johns Hopkins University's Applied Physics Laboratory, explained the effect 'space weather' has on Earth and the discovery of solar flares in 1859 and sunspots in 1908. The constant stream of charged particles known as the Solar Wind was discovered in the 1950s, but scientists struggled to understand how it was accelerated. They also debated why the solar corona is 300 times hotter than the surface, and the drivers behind the 11-year sunspot cycle and

occasional solar storms which now threaten astronauts, satellites and electronic equipment.

The Parker Solar Probe was launched by NASA in 2018 with four sophisticated instrument packages to explore the complex magnetic fields and particle interactions of the Sun's outer corona. It will pass just 6.9 million km from Sun's centre in 2025 at 690,000 km per hour, becoming the fastest manmade object. Costing US\$1.5 billion, it is entirely autonomous, with its instruments protected against solar heat behind bespoke carbon foam.

Parker will use Venus to complete seven solar encounters over as many years. Its first fly-by revealed millions of magnetic fields – first glimpsed by earlier probes in the 1970s – which switchback like roads up a mountain. Uniting the study of surface conditions and the heliosphere, it is thought these fields produce the "pico



flares" from the superheated plasma on the surface and accelerate the electrons escaping coronal holes to 700 km per second. Parker also images Venus on its brief fly-bys and has detected short wavelength thermal emissions from its surface.

A second probe, the joint NASA/ESA Solar Orbiter, was launched in 2020 with 10 instruments to investigate the inner heliosphere and nascent solar wind. Daniel Müller, a Project Scientist on the 10-year mission, explained how 40 cm of titanium foils shield this equipment from 500°C and the delicate engineering required to analyse weak magnetic fields without onboard interference.

The Orbiter will also use Venus to gradually increase its inclination from the ecliptic to observe the solar poles, offering unprecedented insight into the 11-year solar cycle. Scientists believe plasma at the Sun's equator rotates faster than elsewhere, generating asymmetric magnetic fields which allow cooler material to rise and form sunspots. When these fields reconnect, they spark huge flares and coronal mass ejections of electrons and ions into space. Its initial solar fly-by in March 2022 also produced images with 100 km resolution full of "pico flares" a few thousand kilometres high, across the whole Sun.

Combining information from these probes and the new 4-metre Daniel K. Inouye Solar Telescope in Hawaii will

produce a much clearer picture of our Sun's structure and processes, confirming some theories and confounding others in a new golden age of solar exploration.

Increased understanding is vital, as solar events can damage and even destroy modern electronics, despite the protective magnetic field generated by Earth's molten iron core. A massive coronal mass ejection could knock out power grids and communications, irradiate astronauts and devastate the fast-growing fleet of satellites in orbit. Blasting a stream of electrical charges and magnetic fields toward the Earth at five million kilometres an hour, solar storms can also increase the height of Earth's ionosphere, dragging down craft in low Earth orbit. 1859's infamous Carrington Event, the largest solar storm recorded, released the energy of ten billion 1-megaton nuclear bombs and could wreck global power and communication grids if repeated today.

Despite the extreme heat and harsh radiation of the Sun in an unusually intense solar cycle, both orbiters' protective measures are working well, allowing them to observe magnetic fields and particle accelerations impossible to replicate on Earth. Supported by over 50 ground stations, the probes prove that nothing is impossible in space exploration and should inspire future generations to launch even more ambitious missions of their own.

“Extreme exploration of the Sun is one of the most challenging and rewarding scientific frontiers to cross”

## Sea Level Rise, a Crucial Indicator of Global Warming: 30 Years of Space Borne Measurements

“It’s imperative we have the ability to assess the ocean’s capacity for absorbing heat, manage our water resources and understand the impact of sea level rise”

Satellite altimetry combines precise orbital determination with accurate ranging by a microwave altimeter to the ocean surface to calculate its height relative to known reference points or the Earth’s centre. Honed since the late 1970s, consistent global coverage by high-resolution radars has transformed oceanography, revealing the dominance of turbulent 100 km eddies in great ocean currents, rather than a sluggish laminar flow, and highlighting the power of El Niño and La Nina.

Selma Cherchali, Head of the Earth Observation Department at CNES, recalled the launch of TOPEX/Poseidon, a joint

venture with NASA in 1992 which measured surface topography to 4.2 cm. Jason-1, which tracked global ocean circulation and its interactions with the atmosphere, followed in 2001. OSTM/Jason-2 was next to launch in 2008, and Jason-3 flew in 2016 with an improved radar altimeter accurate to 3.3 cm.

Copernicus, the EU’s Earth observation programme, combines information from satellite and terrestrial sources. Sentinel-1A, launched in 2014, was the first of around 20 craft the EU hopes to have in orbit by 2030, and Sentinel-6, launched in November 2020 with a Poseidon-4



radar altimeter and a microwave radiometer, measures ocean heights to centimetre accuracy.

A three-year Surface Water and Ocean Topography (SWOT) mission will take flight aboard a SpaceX Falcon Nine in December 2022. Developed by NASA and CNES and carrying payloads from Canada and the UK, SWOT will complete the first global survey of the Earth’s surface water, observe minute details of ocean surface topography, and record changes in water bodies over time. Its interferometry radar will deliver more accurate spatial resolution than conventional altimeters, mapping the globe between 78 degrees north and south every 21 days. This data will help create two dimensional maps of the ocean surface as well as model rising seas’ effects on floods, deltas, and the salt contamination of agricultural water tables.



Monitoring rising sea levels caused by thermal expansion and melting ice sheets is more important than ever in this age of anthropogenic climate change. Lee Lueng Fu, a Senior Research Scientist at NASA’s Jet Propulsion Laboratory, explained how carbon dioxide from fossil fuel combustion traps heat in the atmosphere. While natural greenhouse gases and water vapour maintain Earth’s average temperature at 15°C, rather than -18°C, excess emissions are boosting temperatures several more degrees. Over 90% of this heat is absorbed by the oceans – Earth’s average temperature would be 67°C without its seas – and so understanding them is vital.

The oceans rose an average of 2 mm a year in the 1990s, 3 mm in the 2000s and 4 mm today. Anny Cazenave, an Emeritus Scientist at CNES, traced the warming of the oceans and retreat of global glaciers in recent years. Polar and Greenland ice sheets are melting, accelerating sea level rise, and several potential tipping points are being reached. Greenland’s vast ice sheet has shed 5,000 billion tons of ice, with 3,000 billion tons lost from West Antarctica. Rising seas threaten coasts and low-lying areas around the world, and could engulf Pacific Island nations.

Orbital and terrestrial data suggests Earth’s ‘climate sensitivity’ will see temperatures rise by 3.5°C if atmospheric CO<sub>2</sub> doubles. Satellites can also detect distinct local variations in sea levels around the world, as well as shrinking lakes and rivers. China’s damming and exploitation of the Mekong River is reducing flows to Vietnam, for example, and many major river systems are under similar threat, endangering millions of people. As well as charting oceanographic change, improved satellite observation is therefore crucial to environmental protection and freshwater management.

The seas have swelled 30 cm since the Industrial Revolution and would continue to rise for hundreds of years if excess emissions ended tomorrow, given the surplus CO<sub>2</sub> already in the atmosphere. Detailed plans to mitigate the effects of future storm surges, river diversions and saltwater intrusion will be required, and must rely on the best satellite data. Future generations will face the consequences of historical use of fossil fuels, but their scientists and engineers will have every incentive to find better energy and environmental solutions to protect life on Earth as well as explore the heavens.



## IAF World Space Award: Achievements of the Tianwen-1 Mission

China's ongoing Tianwen-1 mission to Mars was the first step in its ambitious planetary exploration programme. Launched by a Long March 5 rocket in July 2020, the orbiter, lander and rover travelled almost half a million kilometres to investigate Martian geology, search for evidence of water and sample the planet's atmosphere for at least two years of operations.

The Tianwen-1 team won this year's IAF World Space Award for combining a Martian orbiter, lander and rover in a single launch, their success following the victory of

months later in February 2021. The orbiter imaged the Martian surface for 80 days before the lander was released to touchdown nine minutes later on May 15, 2022, its supersonic descent slowed first by parachute then a brief engine burn.

The landing site lies in Utopia Planitia, the vast Martian plain where NASA's Viking 2 landed in 1976. The region offers an interesting mix of sand dunes, impact craters, mud volcanos and other targets of scientific value, as it may once have been an ocean bed. While the lander is fixed in



Chang'e 4's lunar landing team in 2020. IAF President Pascale Ehrenfreund invited Jilian Wang, the Vice President of the China Academy of Space Technology, to describe the mission's technological and scientific achievements and outline China's roadmap for future explorations and partnerships.

The title Tianwen-1 was chosen after a nationwide essay competition, and translates as 'questions to heaven'. Despite the difficulties posed by the pandemic, air transport setbacks and hot weather at the Wenchang Spacecraft Launch Site in Hainan, the take-off proved a success, and after an intricate series of space manoeuvres, the five-ton spacecraft achieved Martian orbit seven

place, its six-wheeled Zhurong rover rolled down its ramp on May 22 to begin a journey of its own. The 240 kg vehicle covered 1.9 kilometres before powering down to hibernate through the frigid northern winter, but its planned 90 days of operation have already been doubled and could be further extended.

The rover has rocker-bogie suspension to navigate the site's rocky conditions, and highly efficient solar panels to charge its batteries. It carries a sophisticated communication array to send data directly to Earth or use the orbiter for high-speed data relay, and ground-penetrating radar that could detect sub-surface water. Previous missions suggest the Martian surface experienced

“The biggest headache for us was the many, many boulders all over the surface, (...) This forced us to change our strategy for landing operations”

multi-stage water events on a massive scale from 3.2 to 3.5 billion years ago, and indications of more recent water activity have also been detected. The rover will wait for the Martian spring, when more sunlight is available, to resume its odyssey in early 2023.

The orbiter has seven instruments to undertake a global survey of Mars, with cameras of varying resolution, low energy infrared, particle and magnetic detectors and subsurface scanning radar. Its medium resolution camera photographs Mars to a precision of 120 metres, generating images now published in a range of prestigious science journals alongside Mars orbit 'selfies' and orbital insertion videos. More data from Mars will be shared over time, proving the scientific value of such missions and inspiring young people to pursue their own dreams.

Several international partners supported the mission, including ESA. A French laboratory helps analyse the atmospheric data while the University of Berne in Switzerland developed the orbiter's ion and neutral particle analyser, and the mission's magnetometer was produced by a German company.

The Chinese government approved a four-mission planetary exploration programme in 2021. Plans for Tianwen-2, which will return samples from a near-Earth asteroid and visit a main belt comet, are advancing towards a launch

date of 2025, while a 2028 Tianwen-3 Mars sample return and a Tianwen-4 mission to Jupiter, Callisto and Uranus are still at an early stage of design. China is building the capacity it needs to explore the solar system and is looking to partner with other nations, agencies, universities and firms to pursue peaceful scientific goals.

China continues to pursue its lunar programme and remains open to international project proposals for the 2026 Chang'e 7 rover mission to the lunar south pole. The International Lunar Research Station planned by Roscosmos and the China National Space Administration also remains open to international partners. ■



Sunday  
18 September 2022



# IAC 2022

# IAF Global Networking Forum (IAF GNF)



## Roundtable ESA Ministerial 2022

The first day of the IAC 2022 in Paris was filled with an abundance of informative and thought-provoking sessions. Among them was the IAF GNF session “Roundtable ESA Ministerial 2022”, a panel made up of many high-ranking guests: Josef Aschbacher, Director General of ESA; Anna Rathsman, Director General of SNSA and Chair of the ESA Council; Giorgio Saccoccia, President of the Italian Space Agency (ASI); Philippe Baptiste, President of CNES; and Walther Pelzer, Director General of DLR. The roundtable was moderated by Chiara Moenter, Young Graduate Trainee in Strategic Evolution Policy at ESA and Philippe Willekens, Head of Communication Department at ESA.



With this year’s ESA Council meeting at ministerial level (CM22) right around the corner (November 2022) ESA and its Member States are moving towards a major milestone. This brings up many questions: What does it mean? What is at stake? Why is ESA proposing a major step up for the European space Programmes? After a very successful ministerial meeting back in 2019 (Space19+), CM22 represents a package that is a proposed increase of 25% of the budget over three years. Why is this so important, now?

The panel composed of representatives of ESA Member States and the ESA DG talked about the importance of investing in space, recognizing the need to address both the pressing and important issues facing Europe today, and making sure that collaborative effort is taken towards Europe’s future in space.

Josef Aschbacher points out that Europe is in an excellent position when it comes to space, with the power to leverage its unique and top-class level in many domains, including independent access to space, technological sovereignty, key dual use systems, STEM education, and climate action. With the theme of IAC 2022 being “Space for @ll”, Anna Rathsman points out that the need for space is bigger than ever. We need to work together, especially in hard times, and it is wonderful to see that the spirit is good, and everyone wants to achieve a lot.

When discussing the CM22 and the desired results, the answers from the panel were unanimous. Ranging from ensuring the completion of existing programmes while also investing in the future, guaranteeing that all entities work towards a common goal, making sure that all Member States are satisfied with the outcome, all the way to getting a few minutes of sleep in between the two-day council. We look forward to convening after CM22 to debrief!



Monday

19 September 2022

Space 2050: Boldly Going into the Future

During the “Space 2050: Boldly Going into the Future” session, Lockheed Martin shared what they think space is going to look like 50 years from now and beyond.

Their experts took the audience through the not-so-distant reality of when humans expand our presence on the Moon, eventually building up a full-scale lunar economy there. They also walked through technologies in development today that are going to be needed to enable activities like lunar mobility, habitation, and state-of-the-art communications networks.

Beyond this vision for the future of the Moon, Lockheed Martin also highlighted some leading-edge capabilities that will enable us to explore farther out in our solar system than ever before. These included things such as: utilizing the quantum realm to engineer a leap forward in communications; novel imaging techniques; special electronics for artificial intelligence applications; power beaming, and more.

Looking a little closer to home, the team also offered ideas during the session on how humankind can better leverage technology advancements and share data across the globe, in turn helping us better understand and address the risks posed by our changing planet. Lockheed Martin is actively doing this through the Smart Cities infrastructure and the

Fire Fighting as a Service effort. Based on their comments and questions, the audience was particularly interested in the climate intelligence and firefighting efforts.

These technologies being developed now are the key to a bold, new future of space.



Wednesday

21 September 2022

From Leo to Deep Space - What Every Space Actor Needs for Mission Success



Since the dawn of the space age, all space actors have required assured access to radiofrequency spectrum from their location in space to monitor and control their operations and perform their missions. This session addressed how various types of space actors work with a little-known United Nations agency, the International Telecommunication Union (ITU), to gain this mission critical access.

This session, moderated by Audrey Allison (The Aerospace Corporation), brought together a diverse range of key space actors from international and national regulators, space agencies, new non-geostationary satellite systems operators, and geostationary satellite network operators, including Badri Younes (NASA), Julie Zoller (Amazon’s Project Kuiper), Aarti Holla (Global Satellite Operator’s Association (GSOA)), Amar Saidani (Agence Nationale des Fréquences of France-ANFR), and Jorge Ciccorossi (ITU). From their respective roles, the speakers shared their experiences on how they benefit from the ITU’s regulatory mechanisms to achieve the success of their space missions and satellite projects.

The ITU representative summarized its collaborative work with Members States and Sector Members, including space system operators and manufacturers, at ITU Study Groups leading up to World Radiocommunication Conferences, and he described the importance of the industry working with its national regulator and the ITU when considering a new technology or satellite project.

The panellists also highlighted their priorities for the future, including the ITU’s upcoming 2023 World Radio

Conference (WRC-23). WRC-23 includes several space-related agenda items, including enabling mobility applications from non-geostationary satellite systems to Earth stations in motion (such as on airplanes and ships); extending satellite capacity in the Americas region with a new spectrum allocation in 17 GHz range; extending Inter-Satellite Links to allow links between different orbital regimes; making additional spectrum available for science missions to benefit from new technologies; and possible new agenda items for the following WRC in 2027 on identification of frequency bands for in-orbit servicing and new spectrum allocations to support future communications infrastructure on the moon.

In summary, this GNF showcased the importance of spectrum availability and reliability to ensure the success of current and future space missions and how space actors must work with their national regulators and the ITU to create the ecosystem that is critical to support their spectrum needs.



Wednesday  
21 September 2022

## Opening Up of Indian Space Sector- Global Perspective

Post space sector reforms, unleashed by the Government of India in June 2020, a new era of space exploration and space-inspired industries has begun to unfold. There are ample opportunities for everyone from India, to take part in the global space economy and vice versa. An independent nodal agency under Department of Space - the Indian National Space Promotion and Authorization Centre (IN-SPACe) was created in June 2020 “to promote, enable, authorise, and supervise Space Activities of Non-Governmental Entities (NGEs).” Earlier during March 2019, cabinet approved creation of new company “New Space India Limited” to; enhance ISRO - Industry interface & carry out commercialization of ISRO’s space products & services. NSIL is a wholly owned Government of India undertaking / central public sector enterprise, under the administrative control of Department of Space (DOS). NSIL is the commercial arm of ISRO.

Led by Indian Space Research Organisation (ISRO) India’s space programme has impressively evolved for the past 50 years. In terms of technological capabilities India ranks among the top five space faring nations of the world. India

is globally recognised for building low-cost satellites and launch vehicles. ISRO has developed three launch vehicles namely polar satellite launch vehicle (PSLV), geosynchronous satellite launch vehicle (GSLV) and GSLV MK-III. A small satellite launch vehicle (SSLV) is under development and will be operational soon. On satellite front, ISRO has developed communication, navigation, earth observations and scientific satellites.

A new Indian space policy is coming soon to remove all the road blocks that existed in the twenty-year-old policy. Foreign Direct Investment (FDI) and Space activities Bill are in the final phases to ease doing business in India. India’s moon mission Chandrayaan-1 has changed the world’s perspective about India as it discovered water on the Moon. India has developed capabilities in remote sensing, communication and navigation as well.

Indian Government has laid down vision for next 25 years. World is looking forward to work with India because it has strong need and emergence of Indian economy has demonstrated its resilient during major global crisis. We believe in cooperation and power of technology for



the benefit of mankind. India is a leading information technology (IT) nation and has ambition to go digital in the areas of citizen centric services viz. financial transactions, citizens database, resource mapping and planning etc. Space sector plays a vital role in all these services.

The growth of space sector in India will be aided by the vision and policies laid by the Government, to take space sector to next level. It shows aspiration of the country to grow. This can be achieved by developing space application for the public needs. 80% of Indian population lives in village and there is a huge market in services sector. Be it communication, remote sensing, navigation etc., the requirement is huge. This requires faster launch facilities and launches. There is a requirement of thousands of satellites but we have only fifties. Thus, requiring the need for robust supply chain management, strong global cooperation for space industry to grow. This provides new avenues for everyone to contribute and develop frugal technologies like India’s Mars mission. Indian space is no longer controlled by Institutional framework or by Government, its available to all. With new policies, India is open for discussions in all the areas of space. ■



Saturday

17 September 2022

## Short Stay or Long Stay at Mars: An Open Discussion on the Merits and Drawbacks of Different Mission Durations for the First Human Missions to Mars

IAC 2022

Special Sessions



The first Special Session on Sunday was an open discussion considering different mission durations for the first human mission to Mars. NASA's Michelle Rucker opened the panel with a trajectory animation illustrating the complexity of a "short" mission, clocking in at 850 days round trip and nearly 1.8 billion kilometers.

crew in-space, to enhance work performed on a number of ground-based Mars mission analogs. Mohammad Bin Rashid Space Centre's Adnan Al Rais highlighted the UAE's 100-year plan to establish a human colony on Mars by 2117. Culminating panelist remarks with personal experience, Human Research Exploration Analog crew member Pietro Di Tillio shared key takeaways from his time as a ground-based Mars analog crew member and the challenges of isolation and confinement.

Rucker outlined how different driving factors can affect the mission duration, landing location, crew composition and activities – all of which can be accommodated with the appropriate hardware, but the human system is the most important and complex of all. NASA's Jancy McPhee reviewed top human health and performance risks—including radiation, isolation and confinement, distance from Earth, varying gravity fields, and environments—and how mission durations impact those risks. ASI's Livio Narici, ISS4Mars working group member, identified analog missions to conduct aboard the International Space Station to best drive out some of these risks with

Audience members sparked rich discussion around topics of concern related to crew privacy on long-duration missions and technical challenges like entry, descent, landing, and ascent. Significant importance was placed on learning early what the timeline is for a first human mission to Mars and crew composition so that lunar missions can be appropriately designed to address all risk factors. The Special Session did not result in a definitive conclusion about Mars mission duration, but it did reveal insightful perspectives from the diverse audience.

**Saturday**  
17 September 2022

## Space Traffic Management: the IAF/IAA/IISL Initiative



Following the presentation made at IAC 2021 of the first phase of results, the Special Session enabled the Final Presentation of the work performed by the IAF Technical Committee on Space Traffic Management, very much aligned with the 21 UN LTS Guidelines, and gave floor to comments and recommendations from the room thanks to a lively workshop-like set of exchanges. The STM Special Session was fundamental to start disseminating the findings under the auspices of IAF, as requested in the initial MOU.

The goal was to synthesize concepts and facts; identify key attributes of STM; and recommend actions to be taken by the global space community. As such, the focus will be in creating compelling insights and recommended behaviors over a comprehensive review of all dimensions and nuances of the STM challenge. The research activities of this composite group cover essentially all technical topics related to the general STM ecosystem, including: Space Domain Awareness (SDA), which includes military

and national security aspects of space operations; STM, Operational Coordination Services, Collision Avoidance (in orbit, at launch and at reentry), including the link and coordination with airspace users during launch and re-entry operations and frequency management & coordination; SEP (Space Environment Preservation) which includes activities such as Debris Mitigation; Debris Remediation (Active Debris Removal, ADR), JCA (Just in time Collision Avoidance); LDTM (Long-term Debris Traffic Management); SSA (Space Situational Awareness) which includes SST (Space Surveillance & Tracking) and space weather; SOA (Space Operations Assurance) which covers SDA, STM, SEP, and SSA. The interdependencies between topics covered in this report can be categorized as: effective Space Traffic Management (STM) will be difficult to execute without immediate changes in our SEP objectives and behavior. These topics were studied extensively by several working groups across the three organizations between October 2020 and September 2022.

**Monday**  
19 September 2022

## Global SmallSats and Effective Spectrum Management

The Special Session “Global SmallSats and Effective Spectrum Management” invited the audience to learn about and discuss radiofrequency spectrum for smallsats, as highlighted by members of the Commercial SmallSat Spectrum Management Association (CSSMA).

The session introduced the global spectrum management framework before diving into smallsat spectrum access needs. Various commercial satellite operators (Astroscale, Kepler Communications, Kinéis, HawkEye360) and ground segment service providers (KSAT, Leaf Space, SSC) highlighted smallsat applications - including IoT, intersatellite communications, in-orbit servicing and radiofrequency monitoring from space. Advocates for space sustainability (Secure World Foundation) rounded out the presentation portion with advice to question and optimize where sustainability decisions are being taken.

Next, facilitators Laura Cummings (President, CSSMA) and Matteo Cappella (Secretary, CSSMA), invited the audience to choose among topics of conversation.

The attendees indicated a strong preference to talk about the relation between spectrum access and space sustainability

regulations. Whilst binding space sustainability regulations do not exist internationally, countries can - and some do - tie national spectrum access to additional, mandatory sustainability practices; for instance, implementing debris mitigation techniques. When this enforcement is left to the countries, however, it is easy for satellite operators to cherry-pick the most convenient location to authorize their spacecraft activities. This international misalignment can lead to a regulatory race to the bottom among countries willing to attract operators.

A second topic the audience opted to discuss was that of Optical Communications, covering aspects going from best use of optical terminals, to the impact on operations using radiofrequency links. Also discussed was the tricky job left to regulators and industry to define standards and interoperability without hampering competition and technology development.

Appreciating the contribution from the audience, the session concluded with a better understanding of spectrum management. Radiofrequencies and related regulations remain pivotal for the space sector, playing a significant role in space sustainability.



Monday  
19 September 2022

## Responsible Operations in Space

Motivated by the fact that space technology is more and more becoming a commodity and barriers to participation continue to be lowered, this Special Session provided foundational legal, policy, and regulation information aimed at new space actors. The materials for this session were derived primarily from the Handbook for New Space Actors, published by the Secure World Foundation (SWF). The session was designed for two categories of new actors in space: national governments beginning to develop national space policies and regulations; and start-up companies, universities, and all other entities making their first forays into the space enterprise.

In part one of the session, over 50 workshop participants were introduced to international space treaties, legal issues, spectrum management, and the international

company executing a refueling mission in geostationary orbit on a spacecraft owned by one country with which the company had executed a liability agreement valid during the mission. However, the company was licensed by its government, a different state. To make things more interesting, it was revealed that sometime after the refueling mission, the customer's satellite malfunctioned and started to drift, which could cause issues with a satellite owned by a third country.

The participants were divided into four groups comprising the three countries and the company and presented with a set of relevant questions. Animated discussions ensued and each team presented their positions and proposed actions during the wrap-up session. An excellent learning experience was enjoyed by all.



regulatory environment. That was followed by a discussion explaining why and how States create national policy frameworks. Responsible Operations in Space was then introduced from the standpoint of pre-launch, launch, on-orbit, and end of life activities.

The points discussed in the presentation were then reinforced through the execution of a crisis simulation during the second part. The simulation involved a private



Monday  
19 September 2022

## Technological Building Blocks for Exploration and Industrialization of the Lunar Surface

The purpose of this session was to solicit the feedback of the international space community on NASA's plans to develop the building block technologies for the establishment of infrastructure to support the scientific and industrial exploitation of the Lunar surface. Key elements of this infrastructure include landing systems, an electric power grid, systems for the mining and storage of in-situ resources (e.g, oxygen from regolith, hydrogen and oxygen from ice), and technology for construction and manufacturing from materials found in regolith.

NASA's technology leaders in each of these four domain provided brief overviews of development strategy, and

the floor was opened for questions. Discussions were held on topics ranging across all four domains.

The session was quite successfully in soliciting different perspectives on NASA infrastructure, and a number of side meetings were arranged for more in-depth discussions. It is notable that these technology domain plans were also presented in more detail in standard IAC technical sessions. However, the 11-minute-per-topic format of those sessions allowed for very little discussion. This special session was much more effective in eliciting the feedback desired.

Tuesday  
20 September 2022

## Progress in Addressing Biodiversity from Space

Biodiversity in nature is declining globally at rates unprecedented in human history according to the Intergovernmental Sciences – Policy Platform on Biodiversity and Ecosystem Services, May 2019. Karen St Germain of NASA, Steve Volz of NOAA, Yoshihira Arikawa of JAXA, and Simonetta Cheli of ESA collaborated with each other and the audience to give a very rich picture of our critical biodiversity challenge and how space-based observations are helping inform and address the challenge. We learned this challenge stems from changes in land and sea use, direct exploitation of organisms, climate change, pollution, and invasive alien species. St. Germain discussed how the earth system is biology driven, and vice versa. She remarked that differences in scale are a major challenge in understanding, and use of satellite observations helps to overcome these problems. Arikawa gave several examples where satellite observations play a key role to support the transformative change required to reverse trends. These include actions to repopulate coral reefs, fisheries,

wild forests acreage, and mangroves. Volz indicated that we usually cannot easily see the change in biodiversity directly from space. We must often use proxies and second order effects to provide insights. He also remarked that a big challenge is how to integrate satellite-based observations into useful applications. He gave examples such as applications for fisherfolk to reduce catching the wrong species of fish. Cheli talked about the power of international agreements to address biodiversity, essential biodiversity variables, and added to what the other speakers conveyed about integrated information sources. The audience engaged in some great questions to add depth to the dialogue. The result was that all participants learned something they did not know, including the panelists, and that the space community can deliver critical information and capability to inform status and actions. Climate change is contributing to major modifications to biodiversity worldwide; space is critical to tracking the change and helping to create solutions.

Wednesday  
21 September 2022

## Ensuring Sustainable Access to Space for All



Around 80 people participated in the “Ensuring Sustainable Access to Space for All” special session, which was organised in the form of a SpaceQuiz. The audience was divided into teams of up to 5 people that entered into the quiz competition.

The session’s objective was to raise awareness of access to space’s sustainability and environmental impact. The experts provided some initial inputs and take-at-home lessons to the audience in the areas of (i) regulations, (ii) emissions, (iii) life cycle assessment, (iv) ecodesign.

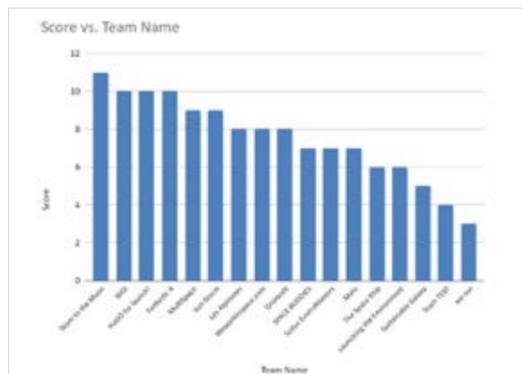


Figure 1: Quiz Session Scoreboard per Team. “Team to the Moon” was the winner!



Figure 2: Answer provided by the audience during the session.

As seen in Figure 1, Figure 2, and the audience’s comments, this session helped augment awareness of the challenges and possible solutions for the explored topics.

The session was then closed by an intervention of ESA focusing on the practical actions that the agency is taking to ensure sustainable access to space. The keynote highlighted how ESA invests in green propulsion and on-orbit servicing initiatives to enhance reusability and extend satellite life.

Going more in detail on the organization of the session, the Quiz was divided into three main types of questions:

- Questions to obtain a final score, Figure 3.
- Multiple answer questions to highlight some challenges on the topic, Figure 4.
- Open questions to obtain audience feedback and engage it in proposing solutions for the analysed problems, Figure 5.

The two groups that gathered the most point were awarded with goodies from ISAR Aerospace, ArianeGroup and SpaceEarth Initiative.



Figure 3: Example of quiz proposed to the audience.



Figure 4: Example of multiple answers quiz proposed to the audience.



Figure 5: Example of open question proposed to the audience..

Wednesday  
21 September 2022

## Human Flybys of Venus A New Science, Exploration, and Adventure Opportunity

The Special Session on “Human Flybys of Venus: A New Science, Exploration, and Adventure Opportunity?” featured a brief 15 minute presentation on a summary report from a recent symposium hosted by the Keck Institute for Space Studies (KISS), followed by an open campfire discussion amongst the whole room regarding the group’s thoughts about the opportunities and challenges related to human fly-bys of Venus.

The summary report, entitled “Meeting with the Goddess: Notes from the First Symposium on Venus Science Enabled by Human Proximity” is one of the first science-focused reports related to potential human missions around Venus that has been produced. The presentation on the report was given by Alexander MacDonald, Chief Economist at NASA, who was a co-organizer of the KISS symposium, along with Noam Izenberg of APL, and





Mallory Lefland of JPL. The report identified a number of human Venus fly-by opportunities and corresponding scientific investigations that astronauts could support when in the proximity of Venus. The report also identified a new double-fly trajectory of particular interest referred to as the 'Venus Back-Flip'.

The presentation was followed by a 50-minute open forum discussion amongst all session participants, moderated by Matt Duggan, Mission Management and Operations Manager at the Boeing Corporation. Kurt Vogel, Director of Space Architectures at NASA, also supported the discussion. There was particularly strong discussion engagement from early-career professionals, from multiple countries, who expressed interest human Venus fly-by mission concepts and provided additional rationales for these types of missions, as well as additional technical and mission implementation options. Overall, the sense from the special session was the human fly-by missions to Venus have value, both as stepping-stones to Mars and independently as interesting missions, and have the potential to expand our horizons in space exploration.

Thursday  
22 September 2022

Protecting the Moon Farside for Scientific Research is Urgent

The Moon is a unique celestial body. It always shows the same face to the Earth. The face on the back (we call it the Farside) can never be seen from the Earth. Because of that, a conical zone exists above the Farside that the human emitted electromagnetic pollution cannot reach; in fact, the Moon body shields all the emissions from the Earth and from satellites orbiting around the Earth.

Thus, the Farside is an electromagnetic pollution free place where radio astronomy could take advantage of.

The Moon has always been out of reach. However, recently, space agencies, public research institutes and private entrepreneurs have shifted their frontier to the Moon. We can think of the Chinese successful Moon exploration program Chang'e 4, or the Netherlands-China Low Frequency Explorer (NCLF) radio antenna onboard the relay satellite Queqiao. If more space probes or satellites should reach the Moon without an international agreement that can protect the Farside, the radio quietness could be spoiled.

Experts on different disciplines and from different countries were gathered to discuss how the Farside can be protected.

NASA presented its scientific missions for the exploration of the Moon; the International Institute of Space Law explained how law can help protect the Farside for scientific research; the ITU, a body of the United Nations, explained what are the laws in place to protect the Farside from unwanted pollution; experts from the Chang'e 4 program talked about the communications between the relay satellite, the rover and the lander; researchers from NCLF described their research.

The goal of this special session and the IAA Moon Farside protection Permanent Committee is to put together all the stakeholders interested in the Moon and let them know of the urgency to preserve the Moon Farside under the aegis of the United Nations.

Thursday  
22 September 2022

The Great Planetary Defense Quiz

The second session on Thursday was the Great Planetary Defense Quiz, aimed to educate the audience in a fun way about planetary defense - the term used to encompass all the capabilities needed to detect and warn of potential asteroid or comet impacts with Earth, and to prevent and mitigate their possible effects.

The session started with a brief introduction of the topic by Alex Karl, the Chair of the IAF Technical Committee on Planetary Defense and Near-Earth Objects, outlining the nature of asteroids and the fact that we have yet to discover most of the ones that can cause significant damage in case of an impact. Potential deflection technologies were presented as well as the current geopolitical framework with the roles of the International Asteroid Warning Network (IAWN), Space Mission Planning Advisory Group (SMPAG) and the UN.

Then it was time for the quiz during which the experts Mariella Graziano, Executive Director Space Systems and Robotics at GMV, Alissa Haddaji, Lecturer on Space Law, Policy and Ethics at Harvard University, and Patrick Michel, Hera Mission Principal Investigator at Centre National de la Recherche Scientifique (CNRS) provided the answers and further information to several questions

covering trans-disciplinary topics involving science, technology, law, ethics, sociology, history and more. The audience submitted questions expanded on the topics presented and went into further details the experts were happy to expand on.

The theatre style setup of the room proved to be an interactive way to engage the audience as they were asked to raise their hands for each multiple-choice option, providing at a glance the opinion of the room for everyone to see.



# 11<sup>th</sup> IAF International Meeting for Members of Parliaments



The 12<sup>th</sup> edition of the International Meeting for Ministers and Members of Parliaments saw the consolidation of the new model proposed for the first time at the IAC 2021 in Dubai. The meeting, now open to ministers and vice-ministers as well, is composed by three sessions where the representatives are invited to take the floor and present their countries' efforts or aspirations in terms of space.



With the participation of 19 representatives from 12 Countries and the European Union this edition managed to bring forward numerous innovative ideas. The discussion focused not only on the benefits that space can bring to societies but also on the ways in which public opinion and legislatives bodies can be better address to obtain the necessary funding to bring space forward.

The President of the International Astronautical Federation (IAF), Pascale Ehrenfreund, opened the event by welcoming the participants and tracing the Federation's growing importance of the meeting as bridge between the space sectors and policy makers for the benefit of societies across the world.

She stressed the role that space can play in answering major terrestrial challenges and urged the fundamental task that Government and Parliament have to convey this

message to the public opinion and securing the support and investments needed to bring space forward.

In her double role of IAF Vice President for Ministerial and Parliamentarians Relations and Co-Chair of the Event, Dominique Tilmans urged for a greater political interest, given the space sector's economic, security and social importance. She continued by underlining the importance of the MMoP gathering due to the importance of having representatives from different countries discussing together and presenting to their peers their countries' challenges and good practices being true to the event's motto "What is possible in your country should be possible in mine too". The welcome remarks then moved to the host country of the IAC 2022 and the MMoP Meeting, France. The first to take the floor was the co-chair of the event, and Chairwoman of the French Senate Committee on Economic Affairs and of the Senate Working Group on Space, Sophie Primas. The Senator underlined the efforts of the French



Parliament and Senate to cooperate on space matters with a special focus on access to space and sustainability. She was followed by Philippe Baptiste, President of the Centre national d'Etudes Spatiales (CNES), who explained that orbital observation is a critical to controlling problems like climate change, and should not be considered an expensive distraction.

Finally, the MMoP Co-Chair of next year's meeting, Soltan Mammadov, Chair of the Working Group for the Azerbaijani-French Inter-parliamentary Relations of the Parliament of Azerbaijan championed his country's progressive agenda and pledged to boost international space cooperation at next year's International Astronautical Congress in Baku.

## Session I - Space for All

The First session of the meeting was opened by a presentation of its moderator, Frederic Nordlund, ESA's Head of European and External Relations. He reported that the overall Investments of the 22 ESA Members reached €7 billion. These fundings are providing incredible data which merge together those arriving from orbital and terrestrial



sources. The goal is that of improving decision making and services in every sector.

Susan Close, Deputy Premier of South Australia, acknowledged the value of space observation to Australia's management of its weather, vegetation, agriculture, energy and minerals. She stressed how much the development of sovereign capacity will promote STEM education, create high-tech jobs and meet the challenges of floods, drought and fires, and climate change. Space surveillance will instead support national security in a turbulent geopolitical age, and new space platforms could even fight climate change through geo-engineering and orbital energy generation.

Nordlund commented on the topics mentioned by Hon. Close by mentioning that the International Charter on Space and Major Disasters has encouraged the dissemination of satellite information to disaster zones since 1999 and is proving more important than ever.

Niklas Nienass, Member of the Committee on Industry, Research and Energy, of the European Parliament argued that additional space investment would strengthen



“With the democratization of space and new players entering the space race, the global space sector has advanced rapidly, generating better awareness of the strategic value of space in all segments of society”

European cohesion by facilitating regional development. The EU's Copernicus programme offers free data to interested organizations, while Galileo improves GPS and a proposed constellation in low Earth orbit could deliver ubiquitous internet to Africa and Europe. He emphasized that space must solve everyday problems to win public support and contribute to integrated information solutions.

Sophie Primas, who chairs the French Senate Working Group on Space, stressed the sector's potential to decarbonize the economy and improve energy efficiency by inventing circular energy environments for space missions.

German Minister of State Sarah Ryglewski continued on the important role that space can play in the fight against climate change and underlined that space-based measures to tackle global issues must be undertaken together. She reminded the audience that the European Commission aims to end net greenhouse gas by 2050, and emission monitoring from orbit will be crucial in achieving this goal.

Klaus-Peter Willsch, Chair of the Germany's Parliamentary Aerospace Group, offered more examples of useful space observation, from traffic congestion and urban planning to protecting nations from foreign attack. Satellites can also bring remote communities online, underpin "smart farming" and direct emergency services in disaster zones.

## Session 2: Space in Disaster and Security Management

Giorgio Saccoccia, President of the Italian Space Agency (ASI), and moderator of the second session of the day, presented how space-based solutions for disaster and security management exemplify the sector's potential to benefit people on Earth. He brought as example the fact that Italy is investing in observation satellites to monitor its potential threats, from earthquakes to environmental degradation.

Vugar Bayramov of the Parliament of Azerbaijan also extolled his nation's space industry and its potential to develop energy resources, strengthen security and diversify its economy. Nigerian Senator Robert Boroffice underlined the power of space, science and technology



to benefit developing countries and listed his country's involvements.

Sérgio Freitas de Almeida, Brazil's Vice-Minister of Science, Technology and Innovation, said his country uses space data to monitor wildfires, floods and deforestation and is developing launch sites and infrastructure to exploit its equatorial position.

South African Parliamentarian Nompandolo Thobile Mkhathshwa saw his country's investment in space as a key tool to monitor and manage floods, droughts and wildfires.

All speakers agreed that space data aids national and international efforts to protect the environment, track climate change, safeguard national security, combat crime and support agricultural, educational and emergency services.

## Session 3: Engaging the Public and Policy Makers in Space

Numerous of the themes mentioned by the moderator of the session, Philippe Baptiste, were then further developed

by several speakers who suggested strategies to encourage public, media and political support for national space agencies and orbital missions.

Mexican Parliamentarian Javier Joaquín López Casarín said politicians had to see space as a productive investment, rather than superfluous cost, amid intense competition for public resources.

Belgian MP Frieda Gijbels agreed that space enthusiasts must emphasize the sector's economic return on investment and crucial role in popular services like weather forecasts and navigation apps. More diverse role models should prove that space is for everyone, and media campaigns should build young people's enthusiasm for space sector careers.

Polish space expert Jakub Ryzenko said crisis management exemplified the utility of orbital observation in times of floods and forest fires. Mehmet Fatih Kacir, Turkey's Deputy Minister of Industry and Technology, praised the democratization and expansion of the space industry and politicians' growing awareness of its strategic and social importance.

Mexican MP Jesús Roberto Briano Borunda positioned space as a key growth sector in the 21<sup>st</sup> century, before attendees urged Heads of State to offer an inspiring vision of scientific progress within a strong framework of international law.

The International Meeting was brought to his conclusion by the final remarks of the the Co-Chairs, Dominique Tilmans and Sophie Primas, who invited the attendees to share with their peers the importance of a similar meeting with the goal of seeing the participation to the event increase even more in the upcoming years. The event was followed by an informal press conference which saw the national representatives and the journalists gather together and discussing various of the topics emerged in the morning sessions. ■



# IAC Hosts Summit - Ninth Session



The interest in hosting the world's premier global space event has never been so in vogue. As a result, this year's IAC Hosts Summit programme has attracted crowds, showing the importance and need for the IAF Members to understand the implications of preparing a bid to host the International Astronautical Congress (IAC).

The Ninth Session kicked-off on Saturday 17 September with a keynote on "IAC Evolution – What's New, What's Next", presented by Christian Feichtinger, IAF Executive Director. The exponentially growing and astonishing figures from recent IACs have culminated in Paris with a record number of 9300 delegates from 113 countries, an incredibly strong participation from the Young Generation representing 42% of the IAC 2022 participants: a robust and multidisciplinary congress programme surpassing 3000 technical papers, 25 IAF GNF Sessions and 20 Special Sessions, and more than 250 exhibitors and 40 sponsors. The IAF Executive Director emphasized new trends characterizing the IAC evolution: the IAC community has embraced non-space actors, there is a growing dimension of the IAC in all its aspects, an important diversity of IAC events, as well as powerful incentives in hosting and planning the IAC such as sustainability, inclusiveness,

innovation and long-term legacy. With all this in mind, the Federation has launched new initiatives which trigger opportunities for enhancing the delegates' experience – just to name a few: the IAF Launchpad Mentorship Programme, the IAF IDEA 3G Diversity Platform, the IAF Space Economic Platform (ISEP) or the IAF International Meeting for Ministers and Members of Parliaments (MMoP). Clay Mowry, new IAF President, will continue this momentum by focusing his 2022-2025 agenda on Sustainability, Investment and Security (SIS).



specifications of the bid, being specific and providing evidence for each commitment and incentive, planning effectively and last but not least, being an active IAF Member to ensure that they have sufficient experience and a good understanding of the IAC programme. A relevant congress theme remains a prerequisite to set a vision for an IAC and helps in creating an added value for the space community.

The third session "The Great Race for Hosting the IAC 2025" deserves well its title. The Call for Hosting the IAC 2025 attracted a record number of bid proposals and the five delegations from China, Turkey, Saudi Arabia, Thailand and Australia were invited to highlight their motivation and competitiveness of their bids. The inspiring presentations unveiled high-quality bids, making the selection process particularly challenging this year.

The last session featured presentations from the Hosts of the IAC 2022 and the IAC 2023 who commented respectively on the unifying congress themes "Space for @ll" and "Global Challenges and Opportunities – Give Space a Chance". This year's congress in Paris has left a strong legacy and will be remembered as the space gathering of all records and the very first environmentally sustainable IAC. The preparations for the 74<sup>th</sup> IAC in Baku, Azerbaijan are already in full swing and the country looks forward to welcoming the global space community. ■

The keynote was followed by a Masterclass on "Mastering an IAC Bid", led by Jan Kolar, Chair of the IAF Congress and Symposia Advisory Committee (CSAC). The panelists, who are also Members of the CSAC, shared their experience and success stories; they also addressed the current and future bidders and reminded them about the logistical, financial and organizational requirements of the bidding process for a large-scale event such as the IAC. When consolidating the IAC bid, bidders shall focus their efforts in streamlining the approach with a committed and experienced Local Organizing Committee (LOC) and Professional Congress Organizer (PCO), shredding the

# IAC 2022

## Closing Ceremony



During the closing ceremony Clay Mowry officially assumed the IAF presidency after Pascale Ehrenfreund. Mowry expressed that he was, "humbled to follow in the footsteps of my friend and colleague Pascale Ehrenfreund as the next President of the IAF".

The four outgoing IAF Vice Presidents were invited on stage and thanked for their contribution to the IAF. The newly elected IAF Vice Presidents were announced: Mishaal Ashemimry from the Saudi Space Commission (SSC), Anil Kumar from the Indian Space Research Organisation (ISRO), Tanja Masson-Zwaan from Leiden

University and the International Institute of Air and Space Law (IIASL), Pilar Zamor from the Colombian Space Agency. Joe Landon, Lockheed Martin Corporation, was announced to be the new IAF Special Advisor.

This was followed by the IAF Award Ceremony that recognizes the many impressive achievements within the space field. It was also announced that the congress successfully fulfilled all the sustainable criteria, and the event could proudly receive its International Organization for Standardization (ISO) certification. The ceremony ended with the IAF flag being handed over to the next Host, Azercosmos, for IAC 2023 in Baku, Azerbaijan. ■



## IAF Astrodynamics Committee

### Introduction

The IAF Astrodynamics Committee was established more than four decades ago and is currently made up of about 30 members. The Astrodynamics Symposium, coordinated by the Committee and conducted annually at IAC, is an international forum for recent advancements in the areas of guidance, navigation & control, mission design, optimization and operations, orbital and attitude dynamics.

### Summary

The trend toward applying artificial intelligence and machine learning techniques in all areas of Astrodynamics is persistent. Innovative paradigms such as reinforcement learning, neuro-fuzzy system and neural networks are frequently applied in new investigations and designs. Trajectory optimization under uncertainty is another highly researched topic. The circular restricted three-body problem is the context of many new developments in orbital dynamics and mission design, operations & optimization.

As far as the applications are concerned, Mars and lunar missions (including transportation and communication hubs in lunar orbit) are in the spotlight, and this reflects also in the growing number of studies in all areas of Astrodynamics in support of the exploration of the Moon and Mars and the construction of infrastructure in lunar orbit. Precise formation flight techniques are being developed for fractionated spacecraft, such as the space gravitational wave telescope B-DECIGO, and in preparation for the realization of a GPS constellation near the Moon. Autonomous optical navigation and trajectory optimization for autonomous asteroid rendezvous for small spacecraft and CubeSats constitute a new trend.

In the area of attitude dynamics, the impact of the fast-developing sector of deep-space missions shows in the control requirements set by the implementation of large antennas and solar arrays and in the operation of solar

sails. As a result, accurate and reliable control of flexible appendages and complex structures is in high demand, and a growing number of studies on the topic are appearing.



*The John V. Breakwell Memorial Lecture at IAC-22 – Jesús Peláez  
(Technical University of Madrid - UPM, Madrid, Spain)*

Jesús Peláez from the Technical University of Madrid, Madrid, Spain (in the photo) received the Breakwell Award from the International Astronautical Federation for his dedication and outstanding research on Space Dynamics, Tethers and Orbit Propagation. Peláez delivered a keynote speech on Electrodynamics Tethers and Orbit Propagation.

### Highlights

During this year, Astrodynamics techniques have enhanced a significant number of missions beyond Earth orbit

- The Double Asteroid Redirection Test (DART) has been humanity's first test of planetary defense. Launched in November 2021, the NASA spacecraft intentionally crashed into Dimorphos, the minor-planet moon of the near-Earth asteroid Didymos on September 26, 2022. DART has been the first-ever mission dedicated to investigating and demonstrating one method of asteroid deflection by changing an asteroid's motion in space through kinetic impact. In a collaborating project, the European Space Agency is developing Hera, a spacecraft that will be launched to

Didymos in 2024 and arrive in 2027 to do a detailed reconnaissance and assessment of the object.



- The Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE) was launched to the Moon on June 28, 2022. CAPSTONE is the first spacecraft to test the Near Rectilinear Halo Orbit (NRHO) around the Moon, the same orbit intended for NASA's Gateway mission, a multi-purpose orbiting platform that will provide support for long-term lunar missions within the Artemis program. The main objectives of CAPSTONE are to verify the orbital stability of a lunar NRHO and demonstrate relative navigation at the Moon. CAPSTONE is scheduled to arrive in the NRHO on November 13, 2022.



- Korea Pathfinder Lunar Orbiter (KPLO also known as Danuri), the first Korean mission to the Moon, was launched in August 2022 on a ballistic lunar transfer to a polar low lunar orbit. Its objectives include the identification of potential landing sites for future lunar missions.
- Launched on December 25, 2021, the NASA/ESA/CSA James Webb Space Telescope successfully entered into a halo orbit around the Earth-Sun L2 Lagrange point on January 24, 2022.
- On September 29, 2022, NASA's JUNO spacecraft performed the closest flyby of Europa since Galileo's passing 22 years ago. The flyby reduced the spacecraft's orbital period and provided detailed photographs of the moon's surface in preparation for the upcoming Europa Clipper mission, scheduled to launch in 2024.
- ESA's and JAXA's BepiColombo Spacecraft is well on its way to Mercury, having performed the second Mercury fly-by in June 2022 with final arrival planned for late 2025.
- ESA's Solar Orbiter S/C has reduced its perihelion distance to less than 1/3 AU allowing an unprecedented view of our mother star.

### Future outlook

New missions enabled by state-of-the-art Astrodynamics methods:

- The Artemis 1 mission will carry several CubeSat payloads of interest, including NASA's LunaH-Map and Lunar Ice Cube missions, which will use ion propulsion to achieve Lunar orbit by low-energy trajectory; NASA's NEA Scout mission, which will use solar sail to an asteroid; JAXA's OMOTENASHI mission, which will test landing technologies at the Moon; JAXA's EQUULEUS mission, which will use low-energy-orbit techniques to enter into an orbit around the Earth-Moon L2 Lagrange point.
- Other lunar missions of note include NASA's IM-1 launch of the Commercial Lunar Payload Services (CLPS) lunar lander, which will carry out navigation demonstration technologies; the Russian Space Agency's Luna 25 (lunar lander) mission; NASA's Prime 1 (Polar Resources Ice Mining Experiment-1) and Peregrine Mission 1 lunar landers; JAXA's Smart Lander for Investigating Moon (SLIM) lunar lander.
- Psyche, NASA's first mission designed to study a metal-rich asteroid, will launch in 2023 and will use ion propulsion to reach its namesake asteroid. A secondary payload on the same launch is the twin Janus smallsats which will reach and investigate binary asteroids and their dynamics.
- ESA's JUpiter ICy moons Explorer (JUICE) will launch and begin its interplanetary journey to the Jovian system in 2023.

### 2022-2023 events:

- The 2<sup>nd</sup> International Stardust Conference will take place at ESA/ESTEC from 7 to 11 November, 2022, and the focus will be on NEOs and space environment management and space sustainability (<http://www.stardust-network.eu/starcon2/>). Two special collections are associated with this event: one on advanced space technologies for the exploration of asteroids (Nature Scientific Reports, <https://www.nature.com/collections/gdfcdaeafb/how-to-submit>), the other on machine learning applications (Celestial Mechanics and Dynamical Astronomy, <https://www.springer.com/journal/10569/updates/23270936>).
- The joint 3<sup>rd</sup> IAA Latin American Symposium on Small Satellites and the 5<sup>th</sup> IAA Latin American CubeSat Workshop will take place between 7 and 10 November, 2022 in Brasilia (Brazil) (<https://iaaspace.org/event/joint-3rd-iaa-latin-american-symposium-on-small-satellites-and-5th-iaa-latin-american-cubesat-workshop/>).
- The 2023 COSPAR Symposium on Space Science with Small Satellites will be held in Singapore from 16 to 21 April, 2023 ([www.cospar2023.org](http://www.cospar2023.org)).
- From 7 to 11 May 2023, Berlin (Germany) will host the 14<sup>th</sup> IAA Symposium on Small Satellites for

Earth Observation (<https://iaaspace.org/event/14th-iaa-symposium-on-small-satellites-for-earth-observation-2023/>).

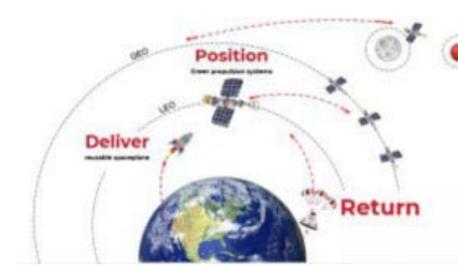
### Committee activities

- The Politecnico di Milano (Milan, Italy) has hosted the 11<sup>th</sup> International Workshop on Satellite Constellations & Formation Flight (IWSCFF, June 7-10, 2022, <https://iwscff-2022.polimi.it/>). The event has gathered experts from science, mathematics and engineering from research institutions, universities and industries to discuss recent advances in the field of astrodynamics applied to satellite constellations, formation flight and proximity operations. The conference covered the following topics:
  - new mission concepts and services for users: the SMEs perspective

- nanosats as an opportunity for fractionation and flexibility ground segment tuning for new space paradigms
- future planetary constellations and formation flying
- challenges in proximity navigation and control
- agency perspectives for new technologies: needs and development plans.

The event was a great success with 80 oral technical papers, 35 of which were from students. The registered participants came from 18 universities, 3 research centers, 4 space agencies and 18 companies.

- The honorary Breakwell Lecture will be held during the Astrodynamics Symposium of the 74<sup>th</sup> International Astronautical Congress (Baku, 2023). The speaker will be announced in the coming months.



Space Renaissance International, a “Space Philo-sophical Organization” created multiple committees amongst others on micro-gravity and leaving in space, including protection from gravity and radiation effects.



### Highlights

The number of licensed commercial flights is relevant and had potential to increase in the United States. Europe is catching up with growing interest in Spaceports,

infrastructures, regulatory aspects. Significant progress has been made by Dawn Aerospace in the development and testing of their Spaceplane. Major focus is on international cooperations and safety.

Announcement was made during the 2022 International Astronautical Congress (IAC) in Paris regarding 0-G Launch and SpaceLand Signed Partnership for International Zero-Gravity Flight Services in Switzerland, Italy, and Mauritius.

### Future Outlook

Increase the networking activities and foster mutual exchange of information and dialog. Monitor the current initiatives for commercial space access and their technological developments. Increase awareness on safety issues and provide advice to the community. Prepare a very successful IAC Congress in Baku in 2023.

### Committee Activities

Foster mutual relationship and network with periodic teleconferences, try to engage young students in the Committee Activities providing support to their university CV development, support industry with recommendations in the specific field, attract more participants in the Committee, spread the word for IAC 2023 in Baku. Encourage attendance to events organized by the International Association for the Advancement of Space Safety (IAASS), including the 1<sup>st</sup> Lunar SAR Conference 13-15 October 2022 (hybrid) and the 12<sup>th</sup> IAASS Conference in Osaka 22-24 May 2023 <https://iaass.space-safety.org/events/conferences/>

## IAF Commercial Spaceflight Safety Committee (CSSC) International Collaboration For Safe Space Operations

### Introduction

The present brief has been prepared to provide an outlook of the major areas onto which the CSSC focused from beginning of 2022. The IAF Spring Meetings in Paris on 28-30 March 2022 was very productive and a great occasion to meet and network in person after the long pandemic restrictions. The great number of received abstracts and their extremely valuable contents anticipated a very successful IAC Congress in September 2022.



### Summary

**SPACEPORTS:** The European Spaceport Forum (ESF) took place at CNES HQ in Paris on 23<sup>rd</sup> September; -main topics included spaceport status update from respective countries; in particular there was a very interesting interaction with Thilo Kranz of ESA on the ESA Boost Programme, the ESA space transportation and support

programme. Other discussion topics included legal process, micro launcher initiative at ESA, relationship between institutional and commercial aspects. Chairmanship of the group was handed over from Sweden to Norway.

**REGULATORY:** Italy is pursuing the regulations for suborbital flights in the Country; while the Spaceport regulation has already been published, a working group is going on, led by the Italian Civil Aviation Authority (ENAC), aimed at generating the Operator Regulation; focus is on the designated site of Taranto Grottaglie Airport.

2021-2022 was a record year for FAA-AST Licensing (13 Flights, 59 Occupants); they also provided support to SpaceX, Virgin Galactic, Blue Origin and Boeing. Licenses issued included 5 for SpaceX and 6 for Blue Origin including first crewed Blue Shepard, 1<sup>st</sup> Private SpaceX Inspiration Flight with 4 paying passengers to orbit, 1<sup>st</sup> AXIOM private flight to the ISS; private EVAs are planned in the future.

Ariane 6 Ground Tests are currently in progress at Kourou Space Center (CSG) to check the Launcher/ Pad compatibility, 1<sup>st</sup> flight is expected in 2023.

Dawn Aerospace is making progress with its Mk 1 Gas-and-go rocket-powered flight and Mk 2 “Aurora” same-day reusable suborbital technology demonstrator. Flight testing are being conducted in New Zealand.

## IAF Committee on Planetary Defense and Near-Earth Objects (NEOs)

### Introduction

Planetary defense is the term used to encompass all the capabilities needed to detect and warn of potential asteroid or comet impacts with Earth, and to prevent and mitigate their possible effects.

A Near-Earth Object (NEO) is an asteroid or comet whose orbit brings it within about 50 million kilometers of Earth’s orbit.

The primary objective of the Technical Committee (TC) on Planetary Defense and Near-Earth Objects (NEOs) is to raise awareness among the global space community, in particular the IAC audience, about the ongoing work within the planetary defense community and to get more people,

especially students and young professionals, interested and actively participating in the field.

### Highlights

#### 1. DART

On 24 November 2021, NASA’s Double Asteroid Redirect Test (DART) spacecraft launched from Vandenberg Space Force Base on a SpaceX Falcon 9 rocket. Its destination was the non-hazardous, binary asteroid system Didymos to demonstrate the viability of the kinetic impactor – an asteroid deflection technology that works by colliding a spacecraft into an asteroid to give it a push years before it would impact Earth in order to move it sufficiently out of the way. On 26 September 2022 DART successfully hit

Didymos' moon, Dimorphos. The impact was observed by several ground and space-based telescopes and continuing measurements of the binary system will allow scientists to compare the actual outcome with the expected one. In 2024, ESA's Hera mission will launch the same binary asteroid system to measure in detail the effect the impact had on Dimorphos after it arrives in December 2026.

### Committee activities

Most committee members will participate in the biennial 2023 Planetary Defense Conference (PDC) from April 3-7, 2023 in Vienna. <https://iaaspace.org/pdc>

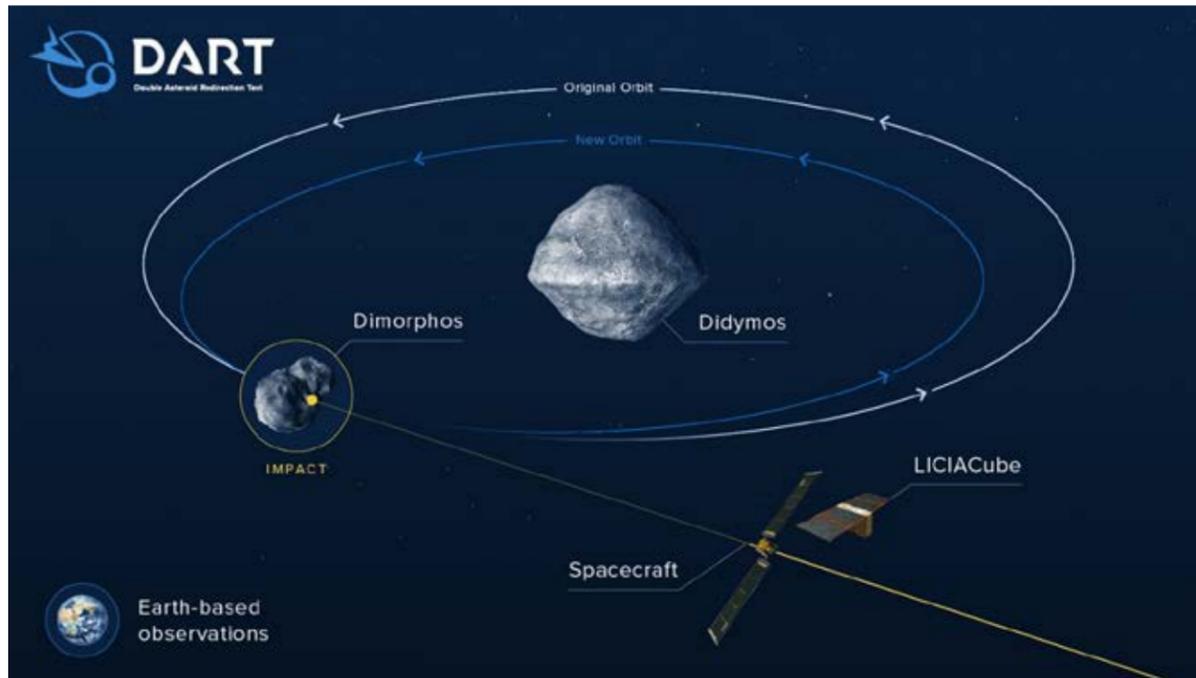


Figure 1- DART kinetic impactor schematic



Figure 2- left: DART approach images with Didymos on the left and Dimorphos in the center; middle: last complete image sent by DART before impact; right: observations by Hubble (above) and James Webb (below) Space Telescopes of the impact.

## IAF Committee on Space Security

### Introduction

Space security has become one of the key topics in any discussion concerning space. The need to strengthen long-term sustainability, safety and security in space is shared by all nations. It is in the collective interest of all peaceful space-faring or space-using nations to encourage the responsible use of space and minimize orbital debris, in order to protect any in-orbit maneuvering spacecraft from a risk of collision and to preserve the space environment.

At the same time, the peaceful use of Outer space, which prevailed in the past, is not to be taken for granted; we are facing a change of paradigm with a contested and conflicting space domain. Today, close approach and proximity operations by foreign objects of satellite-inspection class are already a reality.

We acknowledge the apparition of newcomers and the diversification of space actors, the arrival of large constellations and the multiplication of small satellites, leading to a growing complexity of space operations. There are also moves towards active debris removal (ADR), on-orbit servicing (OOS), rendezvous and proximity operations (RPO), which can be perceived as dual use technologies. This combination of factors and trends brings many opportunities but it also means increasing risks of collisions and interferences, as space will become more and more dense and congested.

In this fast-changing environment, with an increase in both the risks and threats in space, the question of Space Situational Awareness and Space Traffic Management is of the utmost importance. Today, and in the future, we will need to be able to detect, identify, characterize, understand, analyze, attribute and verify what is happening in outer space. An awareness of the highly dynamic and increasingly complex near-Earth space environment appears to be essential to safeguarding space-based assets, ensuring access to space and contributing to the safety, security and sustainability of space in the long run.

The Space Security Committee focuses on a wide spectrum of topics concerned with security, safety and sustainability. More than a technical committee, the Space Security Committee is a high-level policy and strategy Committee welcoming highly distinguished speakers, and fascinating experts as well as researchers from around the globe. From national to international bodies and through multi-actors, the Space Security Committee offers a 360 degrees range of topics and discussions enlightening the space security community as well as the public to a topic that concerns us all.

### Summary

Thanks to its high-level members and distinguished speakers, the Space Security Committee was able to encompass both Vienna, through the Long-Term Sustainability Working Group, and Geneva through the Open-Ended Working Group on reducing space threats, rules and principles of responsible behaviours.

Themes that were approached and discussed by the Committee in 2022 included Space Traffic Management in Europe, Space Situational Awareness, rules and principles of responsible behaviours, global space competition, as well as raising awareness and building capacity.

Indeed, during our Spring Meeting, **Rodolphe Munoz** from the European Commission introduced the topic of Space Traffic Management in Europe, followed by **Carine Claeys**, a special envoy from the European External Action Service who extended the conversation on the EU's international cooperation on STM.

We had the pleasure to listen to **Dick Buenneke** from the US Department of State in order to discuss the newly published United States Space Priorities Framework. **Guoyu Wang** from the Beijing Institute of Technology complemented the Committee Meeting and shared with us the Chinese perspective on space traffic management.

During the IAC meeting, this past September, we had the chance to welcome **Richard DalBello**, director of the US Office of Space Commerce, who highlighted the priority of developing Space Situational Awareness capabilities both nationally and internationally. **Umamaheswaran Raman**, director of the human Space Flight Center at ISRO, shared his experience as the Chair of the Working Group on the Long-term Sustainability of Outer Space Activities, concluding his remarks by pressing that the issue of space sustainability is becoming more and more important and a pressing issue, reminding us that space is for the benefit of humankind and should be taken care of.

His presentation was followed by the one of **Ambassador Helmut Lagos Koller**, Chair of the Open-Ended Working Group on Reducing Space Threats and shared with us the results of the 2<sup>nd</sup> Session that took place just 3 days before the Space Security Committee Meeting. The new approach of the Open-Ended Working Group focused on behaviour rather than capabilities and promoted that norms of responsible behaviours can be a platform to put forward, and it is not solely focused on an antisatellite weapon ban discussion.

**Jerome Barbier** from the Paris Peace Forum presented the Net Zero Space Initiative, highlighting once more the

role of multi actors in space security and sustainability, aiming to raise high-level political awareness beyond the space community at a global scale. Jana Robinson from the Prague Security Studies Institutes reported to the Committee the findings of the Space Security Conference on the Global Space Competition: Security, Markets and Sanctions, finding an ever-greater dependency on space-based technologies and services as well as an increasingly diverse environment in which new private actors are entering.

## Highlights

The Space Security Committee discussions along the year 2022 can be summarized in three keywords, Space Security, Space Safety and Space Sustainability. In fact, space has become a congested, coveted and competitive space where private actors have an ever-increasing role. Indeed, to use Clay Mowry's words, once the purview of superpowers, space is now a domain where multiple actors seek to field new technologies that will investigate, navigate, communicate and innovate. Affordable access is opening new frontiers to researchers, both from government and industry, to explore the very real possibilities of work abroad a future defined by multiple orbital destinations. Sustainability, Investment and Security (SIS) is becoming the new highlight for any space topic where 'security refers to the freedom to operate safely in the space domain', and will live at the core of the security Committee Agenda for the years to come..

## Future Outlook

The main focus of the Space Security Committee in the following years will be **Space Economy, Space Security and Space Sustainability**. The Space Security Committee will also give significant importance to the role of the private sector in relation with the sustainability and security of outer space. For instance, space debris removal or in-orbit servicing. The goal is to identify the commercial capacities in addition to the patrimonial capacities, and to broaden our scope to the importance of investment in relation to space security and sustainability. As Clay Mowry expresses, "We will build a brighter future and ensure humanities' upward march to the stars."

## Committee activities

In accordance with our future outlook and the future of our field, we will closely follow the path set out by Clay Mowry, the IAF President, believing that activities and exchanges centered on sustainability, investment and security are key to promoting cooperation, sharing scientific knowledge, and meet urgent concerns facing spacefaring nations. The Space Security Committee will continue to invite and share its knowledge with high-level experts and researchers in the field of Space Security, encompassing both, national and international bodies as well as multi actors. Continuing the study of the risk level update of space threat, and organizing sessions promoting the submission of our topics.

# IAF Earth Observations Committee (EOC)

## Introduction

The IAF Earth Observations Committee (EOC) is the Committee responsible for organizing, curating and coordinating all EO-related activities at the IAF, namely running the Earth Observations Symposium during the IAC. The Symposium covers all aspects of Earth observations from space, especially observations related to the Earth's environment, including mission planning, microwave and optical sensors and technologies, land, oceanographic, and atmospheric applications, and ground data-processing systems.

## Summary

**Earth Observation is a growing domain of science, business and intelligence**

A wave of Earth observation satellites has been launched in recent years as demand for satellite imaging is increasing due to wars, natural disasters, climate change,

and other events. Global and regional powers around the world are increasingly deploying independent satellite reconnaissance systems, an endeavour that was dominated by the United States and the Soviet Union during the Cold War.

**Rapid tasking of satellite imagery is today a reality across commercial EO providers**

For years, consumers of Earth observation data lamented the time required to task satellites to collect imagery of a specific site. The lag between image order and delivery was typically measured in days and only achieved through lengthy phone conversations. That is no longer the case with new commercial EO players and established ones providing access to cloud-based applications that enable rapid tasking of satellite imagery. Black sky announced Esri's ArcGIS Online Tool; Capella Space and IceEye offer customers access to an automated scheduler through an API; Planet offers a suite of tasking tools for Earth-imagery; Satellogic unveiled its tasking platform Aleph;

Airbus Defence and Space and Maxar Technologies, two companies that have operated Earth observation satellites for decades, also have updated satellite tasking.

**Copernicus Sentinel-1B suffers a major anomaly and is lost**

A major anomaly occurred on Sentinel-1B on 23 December 2021 related to a power system unit. ESA has performed many recovery attempts on the power unit with no success. Consequently, the launch of Sentinel-1C is being moved up to 2023 in an effort to replace the function of Sentinel-1B as soon as possible.

**CNSA launches the BRICS Joint Committee on Space Cooperation on 25 May 2022**

The goal is to promote cooperation in remote sensing satellite observation and data sharing among China, Russia, India, Brazil and South Africa, the five nations forming the economic partnership, BRICS. The joint Committee will guide cooperation on the BRICS Remote Sensing Satellite Constellation to better serve economic and social development in member countries.

**Satellite Images Captured a New Record Low Sea Ice Extent in Antarctica**

After nearly 43 years of observing Earth from space, new satellite images revealed the shrinkage of ice in Antarctica. With images captured this year, scientists reported that ice had shrunk to 1.92 million km<sup>2</sup> in the Antarctic sea, which is 190,000 km<sup>2</sup> less than the record-low observed in 2017.

## Highlights

**DLR launched the first-ever German optical Earth-observing satellite, EnMAP, on 1 April 2022**

EnMAP is a hyperspectral imager with 230 spectral channels in the solar-reflectance range. It will acquire data on a frequent basis with high geometric resolution. On 27 April 2022, EnMAP captured a first light image, recording a strip about 30 km x 180 km over Istanbul.

**Planet secures the largest contract to date and unveils more details of its Pelican constellation**

Planet secured a \$146 million award from the NRO to provide imagery over five years during the company's 14 June earnings call. Also, in September, Planet released additional information about the hyperspectral constellation the company is developing through the Carbon Mapper public-private partnership – Tanager. The satellites' hyper-spectral sensor technology, pioneered by NASA JPL, will provide 30-meter resolution and a full spectral range of shortwave infrared and high-precision 5-nanometer wide bands.

**First NASA TROPICS launch failed to reach orbit – NASA is looking for alternative options to launch the remaining four TROPICS CubeSats**

TROPICS (Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats) is an Earth Venture mission - science-driven, competitively selected, low-cost missions that provide an opportunity for investment in innovative Earth science. It will provide improved time-resolved observations of tropical cyclones compared to traditional observing methods.

**Germany's SARah-1 military radar Earth observation satellite launched aboard a Falcon 9 in June**

SARah-1 is the first of three spacecraft commissioned by the German Armed Forces to replace their long-serving SAR-Lupe constellation. With a mass of approximately four tons, SARah-1 is equipped with an active phased array radar with multiple antenna elements that can be steered electronically. Later in the year, it will be joined by the SARah-2 and SARah-3 spacecraft, which carry passive reflector antennae. SARah-1 was built by Airbus, whereas the overall contractor for the SARah constellation is OHB System AG, from Germany.

## Future Outlook

**Climate change and the summer of 2022 brought more public awareness: more EO for the future?**

The summer of 2022 was plentiful when it came to climate disasters that many people around the globe will not forget. Climate change led to a series of unpredictable and unprecedented weather events for the past months, with catastrophic and even fatal endings. Extreme flooding in Pakistan with the government reporting \$10b in damage; a heat wave devastated the Middle East, Africa, Asia, and Europe with record temperatures that led to droughts and wildfires; tropical cyclones and hurricanes recorded with Typhoon Hinnamnor, South Korea, and hurricane Ina, United States.

**Commercial satellite constellations in the coming decade**

There is increasing activity surrounding EO pay-loads, especially considering the growing New Space Market. The ESA Agenda 2025, "Make space for Europe", states that one of the five priorities for ESA for 2025 is to boost commercialization where member states can benefit from the information products and commercial services of the new and innovative upcoming commercial space companies. The EO constellations, enabled by the agility and commercial viability of NewSpace, will be a major role player in adding to the big data that can be transformed into smart information products.

**Democratization of the EO Data**

Data Democratization is where data is more accessible to all, and therefore there is less of a barrier to retrieving

data. According to a thought leadership on the space sector by PWC in May 2019, “Extracting Value from Earth Observation Data,” there has been an overall decrease in the price for satellite imagery, which is expected to lead to a 4% decline in the existing market. This decrease will, however, be offset by the expansion of the customer base in existing and new use cases. With more data readily available, there are more opportunities for diversification of EO data with new and innovative applications. The conversion can even result in future B2C industry.

**Committee activities**

EOC Technical Sessions at IAC 2022 were well attended and the presentations were of very high quality. Our Interactive Presentations Session was very heavily subscribed and again resulted in the award winner for the B Category on Applications and Operations (making at least 4 years in a row)! Given the steadily increasing interest in EO and GEOSS, the committee requested and was assigned an additional session for IAC 2023, so a major activity was re-organizing most of our technical sessions to update them for balance and new trends and developments. The new session B1.7 was formulated as “Earth Observations to address Earth’s Environmental and Climate Challenges” to ensure a session dedicated to this highest priority topic.

EOC was awarded one Special Session for IAC 2022 in which several Agency Earth Science Directors discussed the state and future of their efforts on Biodiversity, a critical world environmental challenge. It resulted in a very rich discussion with the audience and directors and imparted a good sense of where we are with these very important efforts. Three members of EOC are the IPC Co-Chairs for the IAF Global Space Conference on Climate Change (GLOC 2023), and many others are supporting and are part of the GLOC 2023 IPC so that is a major focus for the next seven months.

In GEOSS, there are three main efforts being addressed, highlights and plenaries proposals for IAC 2023 to maintain the prominence of Earth Observations in the space community and continue our excellent track record of such programmes; coordination and support for the IAF’s role in the intergovernmental Group on Earth Observations (GEO), including preparations for next year’s GEO ministerial where IAF leadership will represent the IAF with support from GEOSS, and supporting the development and execution of GLOC 2023.

GLOC 2023 will take place in Oslo, Norway, in May next year. This conference is the top priority for the members of the Committee for the next seven months, working with the IPC and IAF Secretariat to create and implement the Technical Sessions, Keynotes, Plenaries and support the development of the IAF GNFs and high level content. The IPC will also address a feature at the end of the GLOC that summarizes the outcomes, with the objective to produce a documented outcome.

With the conference theme of “Fire and Ice: Planetary Extremes in a Changing Climate,” and the objective to show that Space is a toolbox for political climate action, the Committee has great expectations for the impact that this conference can have. To create impact, the conference aims for policy and decision-makers to take an active part and enable engagement across Government, Industry, non-Governmental organization, and academic sectors. The planned result is for useful insights, recommendations, actions and initiatives emerge from from those engagements. It is a wish of all the members of the Committee that the conference be a catalyst to share collaborative solutions, challenges, lessons learned, and paths forward among all nations for maximizing the contribution of the space community to addressing the existential global challenge of climate change.

the question: How do we know that we have the right strategy? For example, Harley Davidson, looking at everything happening in the World, considered several models based on foresight scenarios and came up with some gaps to address in their current strategy.

**Highlights**

Two schools of thought on Strategic Uncertainty are:

1. We cannot predict anything, and the world is mostly uncertain. Is ERM really helpful?

For example, stock exchanges in the USA and UK fluctuate quite regularly, no regulators can do anything about it. History shows crashes between a 10% and 20% happen every 16 to 21 years.

2. Or if we have the good set of data, in the era of the Internet, social media, IoT, etc. many things are predictable with AI, now that we are in the Digital age!

Key developed themes included decision speed in times of crisis, preparing for the unpredictable, aerospace & defence top risks, and talent management.

The unpredictability of global economies, in these times of uncertainties and numerous crises, is a key concern. The world is moving quickly, and we must adapt to a rapidly changing environment.

In times of uncertainty, we should act differently. And Risk Managers, in times of uncertainty are the right people to do things differently spend more time on elaborating the strategy, get the right people in the room, and work on the risks and opportunities.

A highlighted topic was risks faced in the Aerospace and Defence sector. They appear to have similar patterns, both address cyber security as a top concern, COVID aftermath and new business models out of it, competition and innovation topics, and reliance on governments contracts.

Some organizations are in a position to question their strategy and their whole model. What makes your organization work? How good are we at anticipating disruptions (e.g. in the supply chain)? These are real questions for Chief Risk Officers supporting their CEOs.

**Future Outlook**

- Strategic risks are most likely to disrupt organizational success (60% of the time) rather than operational or compliance risks
- Focus on the “Heart and Soul” of your enterprise, the value proposition, and strategic capabilities, rather than the noise of operational and external issues
- Expect the age of disruption to continue, we’re not going “back to normal,” so adjust to succeed in this environment

**Committee activities**

The committee received a keynote presentation from Paul Walker, Schiro/Zurich Chair in Enterprise Risk Management at St. John’s University in New York City, on the latest trends in corporate Enterprise Risk Management. Additional details in section 3 of this brief.

In addition, the committee developed key potential themes for its 2023 activities to focus on. Major topics included realizing major upcoming opportunities, mitigating the supply chain repercussions of geopolitical issues, space debris, industrial capacity, communicating risk to executive boards, effective foresight, sustainable business models for the space economy, harnessing disruptive technologies, and terrestrial dependence on space-based capabilities.

Chemoul Bernard, CNES Inspector General, agreed to join the ERM committee as a member, together with Benedicte Fein, CNES internal auditor. The committee will meet again in Paris at the IAF Spring meetings in March 2023.



IAF Enterprise Risk Management Committee (ERMC)  
Risk Management In Times of Uncertainties

**Introduction**

The IAF Enterprise Risk Management Committee (ERMC) met on Wednesday 21 September during the 2022 International Astronautical Congress. The meeting gathered over 20 people, with a majority attending in-person, to discuss the latest advances in ERM, network among risk management practitioners, and share outlooks for the future.

**Summary**

We need to think more globally, integrate the opportunities in our risk management, and be visionary and focus on the strategy. COSO encourages us to analyze risks around setting a strategy, around aligning and finally around executing. When an organization is performing poorly, it is 90% of the time due to a problem in setting the strategy, and ERM practitioners can be of help in that context. CROs can help CEOs on asking

## IAF Human Spaceflight (HSF) Committee

### Introduction

The IAF Human Spaceflight (HSF) Committee organizes the Human Spaceflight Symposium (B3) comprising a total of ten sessions. These sessions include the Overview session (B3.1) and multiple sessions focusing on relevant human spaceflight topics:

- B3.1 Governmental Human Spaceflight Programmes (Overview)
- B3.2 Commercial Human Spaceflight Programmes
- B3.3 Utilization & Exploitation of Human Spaceflight Systems
- B3.4 & B6.4 Flight & Ground Operations aspects of Human Spaceflight - Joint Session of the IAF Human Spaceflight and IAF Space Operations Symposia
- B3.5 Astronaut Training, Accommodation, and Operations in Space
- B3.6 & A5.3 Human and Robotic Partnerships in Exploration - Joint session of the IAF Human Spaceflight and IAF Exploration Symposia
- B3.7 Advanced Systems, Technologies, and Innovations for Human Spaceflight
- B3.8 Human Space & Exploration

The symposium invites papers on all aspects of on-going and planned human spaceflight including the design, development, operations, utilization and future plans of space missions involving humans. The scope covers private and government past, present and planned space missions and programmes in LEO and beyond. The Symposium also features discussions on preparations for the launch of new HSF capabilities and collaborative efforts of human and robotic systems and technologies. Special emphasis is applied to the peaceful use of HSF, fostering international cooperation, and the socio-economic benefit for all mankind.



### Latest Developments

Within the domain of Human Spaceflight the following developments are worth mentioning:

- A. The Plenary 3 which took place on September 19<sup>th</sup>, 2022, entitled “Value of LEO in the Next Decade” was very successful, highlighting a panel of distinguished colleagues including Mary Lynne Ditmar, Olivia Holzaus, Robyn Gatens, Shawna Pandya, and Iwao Igarashi addressing perspectives and insights on plans for future exploration and value of LEO activities.
- B. 2022 introduced a total of 3 commercial crewed suborbital spaceflights aboard Blue Origin’s New Shepard.
- C. 2022 saw 2 crewed civilian orbital missions: Ax-1 and Soyuz MS-20.
- D. 2022 saw a total of 4 orbital crewed spaceflights:
  - a. 2 NASA commercial crewed spaceflights (Crew 4 and Crew 5)
  - b. 2 Soyuz crewed spaceflights: Soyuz MS-21 and Soyuz MS-22
- E. On April 9, 2022 NASA Astronaut Mark Vande Hei returned to Earth after a record-breaking 355 days in LEO.
- F. On September 12, 2022, Blue Origin experienced a booster failure during launch of their uncrewed New Shepard spacecraft, resulting in an FAA investigation to determine whether any system, process, or procedure related to the incident affected public safety. The New Shepard spacecraft is grounded until the FAA determines flight can resume.
- G. The United States, in coordination with its International Partners, is extending the operational



Images: Panel after and during their plenary session in Paris.

- lifetime of the ISS through 2030. Confirmed decommission into Point Nemo.
- H. China Manned Space Program (CMSP):
  - a. Launched the Wentian module on 24 July 2022
  - b. The Mengtian Module should fly in October 2022. Date is still TBD
  - c. Chinese astronauts performed their 1<sup>st</sup> EVA working on Tiangong’s new Wentian module. They completed 2 EVAs in total.
- I. Commercial Space Stations
  - a. As early as 2027 Axiom Space will lead private operational management beginning with new modules.
  - b. Nanoracks, Blue Origin, and Northrop Grumman are working towards their NASA Space Act Agreements for orbital modules.
  - c. Orbital Assembly Corporation has furthered progress on its commercial and research artificial gravity platforms
- J. The Canadian Space Agency (CSA) is establishing lunar surface exploration infrastructure, and commits to work to enhance lunar scientific return plans, and plans to send an astronaut to the Moon with Artemis, fund and build CanadArm3 for lunar exploration, and take a lead in space medicine and health.
- K. In 2022 the third edition of the International Space Exploration Coordination Group “Global Exploration Roadmap” was updated after rapid advances in agency lunar planning for human exploration, corresponding science goals and technology development strategies which included:
  - a. lunar surface exploration objectives have been refined and aligned with current agency goals and new agency aspirations.
  - b. A sustainable operation on and around the Moon is recognized as a shared goal directly contributing to enabling human missions to Mars.
  - c. Key elements for achieving higher levels of sustainability are longer surface missions by surviving the lunar night, and the introduction of reusable elements.
  - d. Analysis related to the potential of In-Situ Resource Utilization, including the use of regolith and water ice on the lunar surface, which may create opportunities in the coming decades.

- H. In orbit, an international coalition of partners will start assembly of the lunar orbiting Gateway. Gateway major components include progress on the Power and Propulsion Element; Habitation and Logistics Outpost (HALO); Deep Space Logistics; International Habitation module; European System Providing Refueling, Infrastructure, and Telecommunications (ESPRIT); External Robotics System; and Airlock with both science and crew capabilities.
- I. The Space Launch System was unable to launch for the Artemis 1 mission due to technical challenges. It is scheduled for a launch window of November 2022. This mission is to demonstrate the launcher and the Orion spacecraft.

### Breakthroughs

As the major “breakthroughs” in the field the following can be considered:

- A. Frequent launch of crewed commercial suborbital missions.
- B. Announcement of up to 3 additional crewed orbital free flier missions through SpaceX beginning with Polaris Dawn first quarter 2023.
- C. China Space Station expansion with 2<sup>nd</sup> and planned 3<sup>rd</sup> modules.
- D. Announcement of Axiom Space and Collins Aerospace who will be responsible for design, development, qualification, certification, and production of space-suits and support equipment for space station and Artemis missions

### Action plan for the year

In addition to the Technical Symposium the Committee is organizing for:

- A. Establishment of the subcommittees focused on Space Habitats, Young Professionals, and Plenary Events.
- B. IAC 2023: GNF planning has been announced. Committee members will propose ideas and potential sponsors for a session.

## IAF Microgravity Sciences and Processes Committee

### Introduction

This Committee Brief has been prepared to give an idea about the main subjects of the IAF Microgravity Sciences and Processes Committee that were presented at the IAC meeting in Paris in 2022. The IAF Microgravity Sciences and Processes Committee organized seven sessions with 63 oral presentations focusing on different aspects of the Microgravity Science. Session topics cover all microgravity science disciplines (material science, fluid physics, combustion science, and fundamental physics), current results and research perspectives, together with relevant technology developments.

### Summary

The major developments of microgravity science relies on activities of Spaceflight vehicles. A limited variety of space-based laboratories can provide microgravity time from several seconds (drop tower, parabolic flights) to several weeks (the ISS). The difficulty of accessing these instruments is proportional to the duration of microgravity time.

Among the new laboratories coming into use and accessible to students and young professionals, who are interested in microgravity and are actively involved in this area, CubeSats should be noted. One of the students in A2.5 session presented not only the payload performance of the CubeSat, but also real scientific results.

The amount of data coming from microgravity experiments is huge and it takes from several months to several years to process them. For example, the overview of the results obtained in DECLIC-DSI facility in 2017-2018 have been presented in Paris. A new approach featured in some of the presentations is to explore how machine learning can help process the large amount of data coming from the ISS experiments.



Microgravity laboratories: Drop tower, Sounding rocket and the ISS

### Highlights

Long-duration exploration missions require on-demand fabrication, repair, and recycling capabilities for critical systems, habitats and maintenance. Manufacturing in open space and inside vehicle are getting important issues to investigate. A significant step towards a closed system is turning waste plastic into 3D printer filament to create new tools and materials. In one of the reports of session A2.2, the first step in the development of 3D printing in microgravity was presented, in addition to the numerical model, the authors conducted experiments in parabolic flight.

### Future Outlook

Future trends in the coming years will be related to the preparation of missions to the Moon and Mars. In the microgravity science, an important attention will be paid to the challenges of materials processing such as regolith. The use of regolith as an in-situ natural resource for construction habitats and objects is desirable to reduce cost. Recent work has shown that lunar regolith can be processed using laser powder fusion, although this requires optimization.

Another important problem is that the regolith adheres to the camera and ranging equipment during the touchdown of spacecraft, and this leads to degradation of the equipment performance.

### Committee Activities

To review and revise description and the content of the session, making them more clear and attractive for the future participants of the International Astronautical Congress (IAC).

## IAF Space Astronomy Technical Committee (SATC)

### Introduction

The combination of ground and Space Astronomy systems has created a time of remarkable discovery and growth. Even though the field of astrophysics is vast, the IAF Space Astronomy Technical Committee (SATC) concentrates its work in the area of space astronomy and in particular, serves as a forum for the exchange of information and interaction between the scientific community, space industry, and space agencies involved in the preparation and the future development of new astronomy missions. Therefore, the SATC action covers the very early phases of mission concepts before these are proposed to the Agencies for assessment. As such, the SATC role is largely complementary and comes ahead of the possible future Agency programmes, allowing SATC to enable or improve the emergence of new science mission concepts.

### Summary

The key development in 2022 is the finalization in January of the deployment of the NASA James Webb Space Telescope, based at the second Lagrange point (L2). The initial images from the telescope, even during the commissioning phase, have demonstrated that the system is exceeding all expectations for its performance and it is now ready to provide key insights to the formation and processes of the early Universe.

Also in orbit at L2, the ESA GAIA mission continues to observe the positions of stars in the Galaxy, leading to the release of a third catalogue in June this year, this adds many new parameters and the number of recorded objects is now more than 1.8 billion. Apart from local stars in our Milky Way, Gaia has also observed many other things such as Solar system objects, as well as extra-galactic objects including Quasars, binary star systems, and of course other distant galaxies.

### Highlights

High-energy astrophysics missions have all achieved significant milestones with Chandra, XMM-Newton and the Integral observatory all exceeding 20 years in mission lifetime and all still contributing significant new results in the X-ray and Gamma-ray astronomy domains.

Together with the JWST, the Hubble Space Telescope also continues to provide high-quality science including both telescopes observing the impact result on the Dimorphos asteroid from the DART mission.

Meanwhile, on earth, the Paris IAC this year has been a great success with all the astronomy technical sessions

presenting high-quality papers and all very well attended – even at times exceeding the room capacity!

### Future Outlook

Given the very high interest in Moon exploration, as a precursor for venturing to other planets, the SATC also wants to explore the technologies that will be needed for effectively enabling experimental research in astrophysics from the Moon, with a special focus on radio-astronomy, astro-particle physics and gravitational wave detection. This means not only the technologies directly related to specific scientific instrumentation but also the technologies required for deployment, operation and maintenance of detectors and arrays of detectors in the dusty lunar environment and cryogenic temperatures at depth in polar craters. It will also be needed to identify and catalogue the sites whose characteristics make them invaluable for science and the conditions that must be met for their preservation and avoidance of interference, in relation to other non-scientific activities that might be carried out concomitantly on the Moon or by spacecraft in orbit around it.

Another key topic is the continuing need to capitalize on and use the synergies between archives of space data. Astrophysics is exemplary in having open data policies, and with new mandates that may come in the United States, open literature and open archives are getting support, and reports are needed to consider the impacts of those policies on Space Astronomy.

### Committee activities

The main SATC activity for the current year are focused on:

1. Long-term analysis of the technical, scientific and programmatic areas of space astronomy. Serve as a forum for the exchange of information and interaction between the scientific community, space industry and agencies involved in the preparation and future development of new astronomy missions. Particular emphasis is on technological breakthroughs for future space applications (e.g. space cryogenics systems, cube-sat constellations, space-ground synergy).
2. Organizing the A7 session for the IAC 2023 to provide a wide range of topics on future space plans by Agencies as well as highlighting current and future technologies relevant to the Space Astronomy community in dedicated sessions at the IAC.
3. Planning for the A7 symposium at IAC 2024 for the discussion and publication of ideas and relevant results and issues to the impact and needs of future astronomical missions.
4. In addition to the IAF/IAC meetings, the committee will also organise several intermediate virtual meetings for members during the year.

## IAF Space CommunicationS and Navigation Committee (SCAN)

### Introduction

The IAF Space Communications and Navigation Committee addresses all aspects of space-based systems, services, applications, and technologies for communication and navigation. This includes fixed, broadcast, high-throughput, mobile, optical, and quantum communication, and position, velocity, and time determination and tracking for navigation.

### Summary

Expansion of services and development of technologies in space communications and navigation is an important part of ongoing space activities, including the return to the Moon. Telecommunications satellite operators continue to grow on their current orbit or new orbits by developing new satellites and building partnerships.

Optical communication has a growing role in satellite communication. More research projects are being implemented on quantum key distribution (QKD) over satellites and artificial intelligence (AI) for optimized use of communication satellite constellations. Growing number of nano-sat constellations for Internet-of-Things (IoT) creates new opportunities for emerging satellite manufacturers.

### Highlights

Laser Communications Relay Demonstration (LCRD), NASA's first technology demonstration satellite for a two-way laser relay system that launched into geostationary orbit in 2021, was certified to conduct tests in May 2022. Experiments are measuring the long-term effects of the atmosphere on laser communications signals, assessing the technology's applicability for future missions, and testing on-orbit laser relay capabilities.

Among several important space communication and navigation related events during the IAC 2022 in Paris, ESA and SES signed the Eagle-1 contract. Eagle-1 will be [the first] European quantum communication satellite with a planned launch date in 2024.

On 26 September 2022, NASA's Double Asteroid Redirection Test (DART) mission demonstrated intentional kinetic impact on an asteroid to change the trajectory of the asteroid. This final phase of the mission relied on a Small-body Manoeuvring Autonomous Real Time Navigation (SMART Nav) system, which performed autonomous vision-based navigation, guidance and control of the DART spacecraft to find Dimorphos and impact it. This mission

demonstrated fully autonomous navigation capability in a deep space mission for the first time.

The European GNSS system Galileo is in the demonstration phase for two new services. The new first service is the Galileo Open Service Navigation Message Authentication (OS-NMA), which started its public observation phase in November 2021 targeting receiver manufacturers, apps developers and research organizations. The data authentication function is freely accessible to users' worldwide, making sure that the data received is indeed from Galileo and has not been modified in any way. The OS-NMA SiS is provided globally with good availability and results were presented by the receiver manufacturer u-blox at the EU Space week in Prague on the 28 September 2022. At the same event, Japanese manufacturer TOPCON presented their first results from the second new service, the Galileo High Accuracy Service (HAS). The Galileo HAS will provide free of charge high accuracy Precise Point Positioning (PPP) corrections through the Galileo signal (E6-B) and by terrestrial means (Internet) offering real-time improved positioning with accuracy less than two decimeters.

NASA and ESA are continuing the effort of establishing the Lunar Communication and Navigation Service (LCNS) through their LunaNet and Project Moonlight missions, respectively. NASA has recently published the LunaNet architecture and interoperability document. Through simulation, ESA has demonstrated that less than 10 m of 3-sigma accuracy is achievable on the Lunar surface using LCNS. NASA and the Italian Space Agency (ASI) are working on the Lunar GNSS Receiver Experiment (LuGRE) to demonstrate GNSS-based PNT capability on Moon. LuGRE will use Software Defined Radio (SDR) receiver to acquire weak GNSS signals at Moon and utilise high-performance tracking, processing and navigation algorithm to provide a PNT solution. ESA-SSTL Lunar Pathfinder mission will use a similar GNSS receiver NAVIMOON to achieve high precision orbit determination accuracy in lunar orbit.

### Future Outlook

Integrated LCRD Low-Earth Orbit User Modem and Amplifier Terminal (ILLUMA-T) will be delivered on board of International Space Station in 2023, to bring laser communications to the orbiting laboratory and empower astronauts living and working there with enhanced data capabilities. ILLUMA-T will gather information from experiments aboard the station and send data to LCRD at 1.2 gigabits per second.

Quantum communication will have a growing importance,

and different technologies and protocols will be tested in space environment. One of the most exciting resources is the entanglement, which will be used for quantum key distribution (QKD) and quantum internet as well. The importance of the field is shown not only by the growing numbers of related projects but with the Nobel Prize in Physics 2022 that was awarded to three physicists working with quantum entanglement.

With the ever-increasing number of LEO satellites, it has become essential to incorporate a robust collision avoidance mechanism in commercial satellites, which requires reliable and high-precision navigation and tracking solutions. Upcoming years will see an increase in demand for near real-time availability of tracking data of space objects for better space traffic management (STM).

LEO constellation-based PNT solution has seen a growing interest. While Xona Space Systems and OneWeb are working towards developing new PNT system architectures with optimized design parameters for LEO-based constellations, LEO signals-of-opportunity-based approaches are also being explored.

NASA is developing Search and Rescue (SAR) capabilities for the Artemis moon missions. Based on the experience

of Cospas-Sarsat, an international satellite system for distress alerting established in 1979, with nowadays SAR payloads on GNSS MEO satellites and various GEOs around the earth. Developing this kind of Lunar Search and Rescue (SAR) service is highly relevant as Lunar PNT (or Lunar GNSS) is also under development and synergies, compatibility and interoperability between this kind of systems in cislunar space are under consideration.

### Committee activities

During the Committee's IAC 2022 meeting, the Committee addressed potential content overlap with other symposia. Actions are planned to coordinate with specific symposia, with a goal to improve the abstract selection process by helping authors to properly identify location for their submissions.

The Committee is exploring the opportunity to begin several activities beyond the IAC symposium. In particular, we are pursuing the creation of SCAN-related playlist of Youtube videos, individual SCAN member introduction videos, and eventually some webinars. Progress will be reported at the IAF Spring Meetings 2023.

## IAF Space Education and Outreach Committee (SEOC)

### Introduction/Summary

The IAF Space Education and Outreach Committee (SEOC) promotes the development and delivery of quality learning and outreach opportunities for students, educators, and members of the IAF, and supports IAF activities focused on students and educators. To achieve these goals, we organize two symposia, a series of events, and an honors and awards programme annually.

### Highlights

Science Communication is being revolutionized by the use of social media, with science communicators and content creators being the main source of education and outreach for many individuals. Another important trend is the rise of mentoring as a workforce development tool, with many programmes being developed within the space sector based on this concept. SEOC is observing these trends, with the aim of supporting these initiatives, and representing them within its technical symposia.

### Future Outlook

SEOC is currently preparing for the 74<sup>th</sup> IAC, which will be held in Baku in 2023. Our call for papers for the Space

Education and Outreach Symposium and the Student Competition has been updated with lessons learned from this year's IAC in Paris and is now available online. SEOC also plans to continue its honours and awards programme, contributions to the Next Generation Planetary and mentorship programmes at the IAF. SEOC Outreach is currently planning several outreach and public engagement activities to be held during the IAC as well.

With changes in the landscape of education and outreach, and a rise in using social media and arts in science communications, SEOC is exploring how to better update its technical symposia for IAC 2024. Our aim is to position the symposia to not only attract scientists and engineers, but also K-12 educators and teachers.

### Committee activities

Throughout 2022, SEOC supported various initiatives, such as the IAF Abstract Mentor Programme and IAF Launchpad Mentorship programme, with SEOC members acting as mentors in both programmes.

The SEOC worked throughout 2022 to plan for excellent support to the 73<sup>rd</sup> International Astronautical Congress (IAC), where we hosted two symposia:

- The Space Education and Outreach Symposium (E1) showcased over 144 papers (selected from over 300 submissions) in 12 sessions around various topics in space education and outreach, workforce development and culture
  - The 50<sup>th</sup> Student Competition Symposium (E2) showcased 52 papers from around the world in 4 sessions, one of which was broadcast online as part of the Global Technical Symposium
- Both symposia showed growth in the number of submissions over the last year, with submissions exceeding pre-Covid numbers.
- SEOC Honours and Awards continued its great work this year, by awarding the following three titles:
    - The Frank J. Malina Astronautics Medal was awarded to Shinichi Nalasuka, Professor of Aeronautics and Astronautics at the University of Tokyo. This award recognizes an educator who has demonstrated excellence in taking the fullest advantage of the resources available to him/her to promote the student of astronautics and related space sciences. Professor Nalasuka was also a keynote speaker at the SEOC E1 Symposium.
    - The Luigi G. Napolitano Award was awarded to Julia Briden. This award is presented annually to a young scientist (below 30 years of age) who contributed significantly to the advancement of aerospace sciences and presents a paper on this contribution at the IAC.
    - The IAF Student Awards recognize the best papers presented by students at the IAC in the undergraduate, graduate and student team categories.
      - » The Undergraduate Category 3AF Gold Award was awarded to Jorge Moreno from the Universidad Politécnica de Madrid, Spain for the paper ‘Development of an Improved Random Positioning Machine to Simulate Organic Growth in Microgravity’
      - » The Undergraduate Category Hermann Oberth Silver – IFR was awarded to Sanmathi Priya Abiram Lakshmi Devi of Cornell University for the paper ‘Harvesting Geothermal Energy on Mars for Future Settlement’
      - » The Graduate Category Hermann Oberth Gold – IFR and the British Interplanetary Society Prize for Best Technical Paper were awarded to Franco Maria Marchese and Claudio Rapisarda of Delft University of Technology for the paper ‘Detailed Design and Verification of a Wave Spring Self-pressurized Tank for a Micro-resistojet Thruster’
      - » The Graduate Category 3AF Silver Award was awarded to Brendon Cavainolo of the University of Central Florida for the paper ‘Simulating Melting-solidification of Lunar Regolith Particles Using Coupled CFD Methods’
      - » The Hans von Muldau Team Award for the Best Team Project was awarded to the ISAE-SUPAERO team (represented by Timothée Simon) for the paper titled ‘Preliminary design of lunar vehicle for astronauts transportation’.
- SEOC members contributed to the selection of the IAF Emerging Space Leaders (ESL) Grantees and the IAF Young Space Leaders (YSL) Award programme as well. We are happy to see Ozan Kara of SEOC among the awardees of the YSL this year.
- SEOC members (alongside the IAF WD-YPP and other committees) also supported the Next Generation Plenary (NGP) programme as steering committee members. The NGP this year organized the Next Generation Plenary ‘AI4Space: Perspectives from the Next Generation’, while also holding an additional panel at the International Student Zone titled ‘Space and the Arts: From STEM to STEAM’. These efforts will continue in 2023.
- SEOC Outreach team has relaunched its programmes, with plans in place for activities in 2023 for engaging the public and education and outreach as part of IAF events. SEOC members also contributed to the activities of the International Space Education Board, which held several events for students. Finally, SEOC saw one of its largest meetings at the IAC 2022 in Paris this year, with an overflowing room and many prospective members joining to learn more about our activities.

## IAF Space Entrepreneurship and Investment Committee (SEIC)

### Introduction

The IAF Space Entrepreneurship and Investment Committee (SEIC), previously known as the EIC, was inaugurated in 2007, promotes dialogue among entrepreneurs, established companies, government,

and academia, focusing on space economic innovation and PPP. Coordinates E6 Symposium that addresses traditional space industry applications (e.g., satellite-based services involving Earth observation, navigation, and communications) and new space industry applications (e.g., space tourism, space-

industrialization, space resource utilization). We want to congratulate our distinguished SEIC member Clayton Mowry (Voyager Space and former Blue Origin), who is the new IAF President. Clay officially took over from Pascale Ehrenfreund in October 2022. We also want to welcome our new SEIC leadership. Warm thanks to Ken Davidian (FAA), our former Chair, welcome the new elected Chair, Nancy C. Wolfson (AIAA), and our new Vice-Chairs, Gary Martin (AIAA), Ken Davidian (Former-FAA, Current-ISU), and Joerg Kreisel (AIAA). Our IAF-SEIC Page: <https://www.iafastro.org/about/iaf-committees/technical-committees/entrepreneurship-and-investment-committee-eic.html>

### Summary

In 2022 the space industry is experiencing exciting new developments that seek to foster the commercialization of space, sustainability, and public-private cooperation. **NASA's Artemis 1 mission** on the Space Launch System (SLS) rocket shows the importance of public-private partnerships as we see NASA and its industry partners, such as Boeing and Lockheed Martin, collaborating in another launch attempt scheduled for Nov 2022. **The International Space Station (ISS)** is expected to retire after 2030. Besides being a platform for ground-breaking research impossible to replicate on Earth's surface, the ISS will be remembered as an example of public-private cooperation and international collaboration. In **2021-2022 Blue Origin** unveiled plans for a commercial space station. **Astroscale Company** aims to support the sustainable use of space with satellite end-of-life services and active removal of space debris. Australian startup **High Earth Orbit Robotics** combines intelligent control with space-based cameras to acquire high-quality imagery of satellites, space debris, and resource-rich asteroids.

### 3. Highlights

**A) - THE SEIC BUSINESS PLAN COMPETITION (BPC) AT THE IAC 2022, PARIS, FRANCE:** The NewSpace Business Plan Competition (BPC) was a cooperation between The Space Entrepreneurship and Investment Committee (EIC), The Center for Space Commerce and Finance (CSCF), World Space Week Association and Space Generation Advisory Council-Commercial Space Project Group (SGAC-CSPG). During our three-day event, experts Candace Johnson, Dennis Stone, Joerg Kreisel, Thomas A Olson, Nancy C. Wolfson, and Nicholas Florio explored innovative approaches for public-private partnerships (PPP) for space exploration, satellites, resource utilization-asteroid mining, space debris solutions, and more. The BPC was especially valuable for young professionals considering entrepreneurship paths, early-stage startup founders, and investors. The judges mentor our finalists during the **BPC's Entrepreneur Boot-Camp on Sept 18-19**. The grand finale was **The BPC's Panel-Pitch Session on 20 September**. Our finalists were Celestial (Germany), KMI (USA), Progresja (Poland), Spin (Luxembourg), and Astralintu Space Technology (Ecuador); they competed for the grand prize of USD 10,000! Special thanks to IAF

Bureau and IAF Secretariat for their fantastic job assisting the BPC. We also wish to thank Thomas A. Olson (main proposer), the past SEIC Chair Ken Davidian, to whom this initiative was first introduced and proposed in 2020, and the current SEIC Chair Nancy C. Wolfson, for her leadership in managing the project development, partnership coordination, and for obtaining the IAF Bureau approval for the BPC implementation at the 73<sup>rd</sup> IAC 2022, Paris, France! Thanks to our On-Site Lead Coordinator Alina Vizireanu and our Promotion Co-Coordinator KangSan. Contact the BPC Project Managers: Thomas A Olson at [tao@cscf.space](mailto:tao@cscf.space) and Nancy C. Wolfson at [NancyPlanetaryDefense@gmail.com](mailto:NancyPlanetaryDefense@gmail.com)



**B) - THE SEIC AT THE SPACE RESOURCES WEEK CONFERENCE IN LUXEMBOURG:** Luxembourg adopted the Act on the Exploration and Use of Space Resources, and The Minister of Economy of Luxembourg, Franz Fayot, signed the Artemis Accords (The Artemis Accords support that space resource extraction and utilization goes accordingly with the Outer Space Treaty-Articles II, VI, and XI). In 2022 The Luxembourg Space Agency had another fantastic “Space Resources week Conference.” SEIC members attended the “Space Resources Week Conference,” and our SEIC Chair Nancy C. Wolfson was invited to take the ISU “Professional Space Resources Course” in person and received her certification at the Space Resources Week Conference.

**C) - THE SEIC AT THE ARTEMIS 1 LAUNCH, FLORIDA, UNITED STATES:** The Artemis missions are critical to the space economy, fueling new industries and technologies as we establish a sustainable human presence on the Moon. Our NASA associates invited various SEIC members to join the launch of Artemis 1 in-person on-site in Florida-United

States, including Chair Nancy C. Wolfson; she traveled to Florida for the second Artemis 1 launch attempt; unfortunately, the launch was scrubbed again and moved to November 2022. We will keep you posted.

### Committee activities

We are moving forward with a new exciting term! The newly elected Chair, Nancy C. Wolfson's Management Agenda, lays out a long-term vision for the committee to participate in the larger international conversation on the new trends in space commercialization, public-private partnership (PPP), along with new space industry applications, including space tourism, space-industrialization, space resource utilization-asteroid mining, solutions and commercialization of orbital debris, and similar activities with emphasis on increasing young professional involvement in the field. In 2023 the SEIC leadership and members will be working on: **ACTION 1**-The SEIC Working Groups (WG) in cooperation with various institutions and organizations. WG#1-SUSTAINABILITY AND SPACE RESOURCES UTILIZATION, WG#2-SPACE PUBLIC & PRIVATE PARTNERSHIP FOR MANNED-UNMANNED MISSIONS, WG#3- SPACE INVESTMENTS & NEW BUSINESS MODELS. **ACTION 2**-New term's agenda includes strategic steps to increase attendance and abstract submission for the E6 Symposium in 2023. She started this new approach in 2022

by developing closer communication with the IAF network, WD-YPP, and others. **ACTION 3**-To develop a strategic plan for the "Award for Small Enterprises" proposed by Gary Martin in collaboration with Ken Davidian, Lisa Labonte, and Nancy C. Wolfson. **ACTION 4**-Proposal by Christian Sallaberger to connect the ISU and the EIC to support each other's activities.

The SEIC annual events at the IAC 2022 were successful, thanks to the great SEIC teamwork! **The SEIC-E6 "Business and Innovation" Symposium**, which includes technical Sessions E 6.1, E 6.2, E 6.3. We noted the high quality of abstracts received, and the attendance exceeded our expectations. Our E6 Symposium got 127 abstracts submitted from 34 countries to the 5 different EIC-E6 Sessions.

**Symposium Keynote Speakers**, Rainer Horn and Nancy C. Wolfson presented: "New Economy for Commercial sustainability Driving Space Resources Utilization and PPP" <https://www.iafastro.org/events/iac/iac-2022/technical-programme/symposium-keynotes/e62-new-economy-for-commercial-sustainability-driving-space-resources-utilization-and-ppp.html>

We conducted our annual "Space Is Business" **Paper-Writing Competition** in conjunction with the Space Generation Advisory Council (SGAC). To join our SEIC email list please email: [NancyPlanetaryDefense@gmail.com](mailto:NancyPlanetaryDefense@gmail.com)

ongoing missions: Mars Express, HOPE and INSIGHT. A set of talks was more oriented towards technology, in particular in the field of rover navigation, communications and heatshield.

The 1<sup>st</sup> session was extremely well attended with almost 300 people in the audience, twice as much as in the afternoon. Altogether, 17 presentations were given out of 20 that were expected at the conference. The total number of candidates abstracts for the Mars sessions was 61, with 10 assigned as IPs.

The session on Small Bodies Exploration was separated into a part A (Wednesday) and part B (Thursday). Part A was focusing on missions in operation and such in implementation. After the great success of the Hayabusa2 principal mission the plans for mission extension have been presented by Shota Kikuchi. The Psyche mission to an M-class asteroid. To be launched next year has been presented by David Seal. The JAXA Mars Moon eXploration (MMX) mission, to be launched in 2024 was represented by a mission overview (by the Program Manager, Yasuhiro Kawakatsu, as well as dedicated presentations on the CNES/DLR provided MMX Rover, the Raman Spectrometer RAX and the IR spectrometer MIRS. Part B covered aspects of asteroid mitigation (e.g. presentation by Dr. Patrick Michel on the Hera mission), an overview on the Janus mission by Dr. Dan Scheeres, as well as more general talks on technologies and mission concepts.

The Solar System Exploration including Oceans Worlds session was very well attended along the entire durations (up to 150 persons). Many student presentations were

made, some of them with a very high level of quality. At same time most of the presentations are still mission early studies or master thesis. The session needs to attract more space agencies to make visible planned operational missions in the area. As co-chairs we have an open action on this topic.

### Future Outlook

Many amazing missions are about to be decided and the actual architecture of the ARTEMIS programme will have to be baselined. Moon and Mars exploration remain targets of many countries either in cooperation or as stand-alone (like the case of China) the important will be to federate the mission experience and results to allow for dynamic development of the whole space exploration.

### Committee activities

The Space Exploration Committee has already very outstanding participation from Agencies, industries and research center, this allows for a very rich exchange on progresses and long term strategies exchange. Due to political reasons it is difficult to enlarge this to certain countries namely Russia and China. Despite that there are many requests for joining the committee and those are scrutinized by the actual members.

During the last meeting it was discussed to propose the IAF the possibility to consider a number of Plenaries/GNF, for the IAC 2023 in Baku, on the following themes: ARTEMIS, Jupiter exploration and HERA/DART mission. Members in charge of those task will come up with proposals.

## IAF Space Exploration Committee (SEC)

### Introduction/Summary

**Space exploration** has always been considered as the discovery and exploration of celestial structures in outer space by means of continuously evolving and growing space technology, the physical exploration of space being conducted both by unmanned robotic probes and human spaceflight.

Today space exploration is also targeting commercial use, the consequence being that newcomers are reaching the space arena, competition is becoming more aggressive and completely new scenarios are identified.

### Highlights

To address all aspects of the space exploration areas of interest have been identified and assigned to each panel. These are the highlights derived from the sessions during the Paris IAC.

The Space Exploration Overview was extremely well attended with engaged audience members. Updates from

the COSPAR Planetary Protection Committee were shared and the audience gained a good understanding of how data from recent missions to the Moon and Mars are informing the COSPAR guidelines. NASA, the International Space Exploration Coordination Group (ISECG) and the UAE shared the status of exploration plans.

The Human Exploration of Mars was very well attended with very interesting presentations. A large number of student presentations were made. Of particular interest to the audience were the results from the first 18 months of operation of NASA's MOXIE Mars Oxygen generation payload and the implications of this technology to future human missions.

In the Mars Exploration we had the privilege of a very elaborate keynote paper, jointly presented by major program leaders of ESA and NASA, about Mars Sample Return. MSR is definitively the major mission of this decade. This was complemented by thorough presentations of the Capture, Containment and Return System, and of the Sample Transfer Arm of MSR. We also benefited from several excellent presentations of the results of three

## IAF Space Habitats Committee (SHC)

### Introduction/Summary

The IAF Space Habitats Committee (SHC) aims, in cooperation with other IAF committees and symposia, to foster interest in the importance of building an international and interdisciplinary understanding of the issues and stakes raised by future space habitats (e.g., settlements on celestial bodies and orbital infrastructures).

### Summary

The past few months have highlighted how much human space exploration is a fast-evolving field, while commercial programmes and future Moon missions further take shape. Space habitats, including suits which are considered a form of habitability infrastructure by many experts, are a core dimension in these evolutions. While SpaceX continued launching NASA and international crews to the

International Space Station (six missions as of October 2022) and prepares the first-ever commercial EVA for 2023 as part of its **Polaris Dawn programme**, Axiom was officially granted by NASA in early September 2022 the agency's task order to build the generation of spacesuits to be used for Artemis missions (from Artemis III). From 8 to 25 April 2022, Axiom also realised the first all-private astronaut mission aboard the International Space Station (Axiom's Ax-1 mission), launched with SpaceX's Falcon 9. Except for the mission's Commander, former NASA astronaut Michael Lopez-Alegria, the Ax-1 crew was exclusively composed of philanthropists and investors, further highlighting the great evolution of astronauts' profiles and training. This evolution towards private missions relates to an increased need for renewing space habitation interior designs and capabilities to fit life in orbit beyond work. In the meantime, the future of the ISS has been extensively discussed among partnering agencies, while the utilization of the station

has been extended to 2025 and thorough assessments of its technical reliability past this date are underway.

**Highlights**

The launch of NASA/SpaceX Crew-5 on 5 October 2022, as the first US-based commercial launch to the International Space Station including a Russian crew member, highlights the core importance of considering, and further developing, interoperability standards in future space habitability structures. In the continuity of the International Space Station, interoperability is expected to play a central role in future surface and orbital infrastructures to facilitate global partnerships and long-term adaptability (including in the Gateway and any future nationally led space station open to international cooperation). Commercial missions mentioned above (cf. section 2) also imply important technical developments, including the development of SpaceX Polaris EVA suits, Axiom’s ongoing construction of the first commercial space station, ThinkOrbital multimission platforms, and many other private initiatives fostering innovation, modularity, adaptability and sustainability. In addition, and after several delays, Boeing’s CST-100 Starliner test flight scheduled for late 2022 will hopefully lead to the vehicle’s validation and allow to further strengthen the diversity of transportation vehicles available for future crews.

Furthermore, many SHC members currently work on developing new technologies and techniques for future space habitats. These include a multi-disciplinary study investigating how pavement elements from lunar regolith can be laser sintered into infrastructures (e.g., roads and launch pads), research on mission and system requirements to allow compatibility and modularity of future infrastructures through standardization, and the further development of a ground test demonstrator for the EDEN ISS Mobile Test Facility (MTF) greenhouse for integration to ESA’s LUNA facility. Some pedagogical developments by SHC members can also be emphasized, including the creation of the MBA Space Architecture at the Technical University in Vienna.

**Future Outlook**

Lunar missions are currently an important focus in space habitats research, focusing on the challenges associated with long-term to permanent settlements on our natural satellite. Technologies and systems relevant to closed-loop habitats, infrastructure elements and power generation and storage are key research aspects. Furthermore, governance, standardization, and human factors in general, are also important fields for research. As illustrated by the previous sections, the Low Earth Orbit becomes increasingly interesting for future commercial space stations, with production, tourism, and science as core tasks, benefiting from the heritage of decades of ISS operation and utilization. For both areas, an economy and market are also researched, understanding how a market

can be built to enable companies who have to operate profit-oriented, in supporting or even leading habitat operations. All aspects of this emerging space exploration ecosystem need to be further addressed through thorough research programs, i.e., not only the economic and technical feasibility of these programs but also their legal, cultural, ethical, and environmental dimensions. A minoritarian, yet growing, focus on indigenous design, technologies, and culture within the space field, highlights how diversifying our frameworks could lead to innovative and more sustainable approaches to space habitats in the coming years. This interest directly results from an increasingly diverse community of experts involved in space habitability projects around the world, both in terms of disciplines (anthropology, indigenous studies, etc.) and cultures.

**Committee activities**

In addition to continuing developing a shared database via Google drive including resources of interest for SHC members (membership application supporting documents, collective work documents, ongoing project databases, interdisciplinary virtual library on space habitats-related topics, etc.), Committee’s activities for the upcoming semester include:

- **Yearly online workshop.** Following the first iteration of a webinar, organized on Zoom in January 2022 by the Committee’s chairing team (Olga Bannova, Sandra Häuplik-Meusburger and Julie Patarin-Jossec), the SHC has decided to set up a yearly iteration of an online workshop allowing both current and prospective members to present their research and work. The organization of this event is to be handled by a team of rotating SHC members.
- **Yearly article in ROOM magazine.** Among its initiatives to foster cooperation between its members and the benefits of its activities, the SHC will be publishing each year an article in **ROOM magazine** focusing on some of the latest research conducted by its members. Forthcoming in December 2022, the first iteration of this publication will be edited by a team whose members will rotate every year.
- **Cross-committees initiatives** and technical activities. The SHC will continue its cooperation with other existing IAF symposia and technical committees, including the symposia E5 “Space and Society” and D3 on “Building blocks for future exploration and development” through joint Technical Sessions (E5.1, D3.2A). The SHC is also actively working with the Human Spaceflight Committee to organize a joint technical session and/or submit joint new session proposals for future IACs, including in the plenary format. The SHC will also continue the technical session it has implemented for the IAC 2022, E5.6, “Simulating space habitats”, for the IAC 2023. Based on feedback collected at the IAC 2022 in Paris, the SHC has updated its call for proposals for the IAC 2023, including in encouraging increased cross-disciplinary research in submitted papers.

Considering a few SHC members are active members or chairs of the AIAA Space Architecture Technical Committee, both committees also maintain strong collaboration, as

highlighted by both the IAC Space Habitats Sessions from 19 to 22<sup>nd</sup> September 2022, and the AIAA SATC symposium organized in Paris on 23<sup>rd</sup> September 2022..

IAF Space Operations Committee (SOC)

**Introduction**

The IAF Space Operations Committee is covering all aspects of human and robotic spaceflight missions and involves many organizations and industries across the globe, which are active in this field.

**Latest Developments**

During its regular committee meetings member organizations and industries provided their report on the latest status.

ESA reported on the latest operations status of its missions:

- The Bepi Colombo mission en route to Mercury has achieved its second of 6 Mercury fly-bys and is planned to finally arrive there in December 2025;
- Solar Orbiter also recently achieved another fly-by around Venus (September 2022) to change its orbit observing the sun;
- ESA’s TGO and Mars Express missions provided continuous data relay support to surface probes and rovers from different countries on Mars;
- The Gaia Astrometry mission operated by ESOC release its 3<sup>rd</sup> star catalogue with around 1.8 billion objects and stars leading to the world’s science community.

JPL reported on the latest status of its Mars exploration and the achievements since the first missions and rovers to the red planet. See also <https://vimeo.com/731884430/78270c7266>.

DLR reported their latest status as follows:



The Eumetsat status is shown in the next figure:



**Highlights**

Following its successful launch on an Ariane 5 from French Guiana the James Webb Space Telescope has completed its commissioning phase. Several papers and presentations on this achievement were presented during the IAC 2022 in Paris.

The Committee has also submitted and supported the successful application of Frederic Nordlund, ESA, for the IAF Excellence Award in International Cooperation, which was awarded to him during the IAC 2022.

**Future Outlook**

The SpaceOps community is preparing for the upcoming 17<sup>th</sup> **SpaceOps conference (SpaceOps 2023)** taking place from 6-10 March, 2023 in Dubai, United Arab Emirates, which will be hosted by the **Mohammed Bin Rashid Space Centre (MBRSC)**.

Several of the members are looking forward to new launches:

- The Artemis I mission to the moon still in 2022
- ESA’s Juice mission (Jupiter), Euclid (a mission to explore the “dark universe”), Sentinel-1C (joint mission with the European Union) – all slated for launch in 2023;
- Eumetsat and ESA are planning to launch Meteosat Third Generation (MTG) meteorological imaging satellite at the end of 2022 and the MTG meteorological sounding satellite as of the end of 2023.

### Committee Activities

The IAF Space Operations Committee joins the SpaceOps organization in a new initiative (called Space Operations Committees Alumni, SOCA). SOCA's objective is to

establish the historical continuity between space operations of the past and those of the future and to foster cooperation and knowledge transfer between "old" and "young" generations of engineers and scientists in the field of space operations.

## IAF Space Propulsion Committee

### Introduction

The Space Propulsion Committee addresses sub-orbital, Earth-to-orbit, and in-space propulsion. All types of propulsion are of interest to the committee: chemical and non-chemical/electric propulsion, but also advanced, unconventional, or air-breathing propulsion. The symposium sessions organized by the committee during the yearly International Astronautical Congress include: liquid systems (2 sessions); solid and hybrid systems (2 sessions); electric propulsion (2 sessions); small satellite propulsion; nuclear propulsion and power systems; propellantless propulsion; air-breathing rocket propulsion; disruptive propulsion systems enabling new/visionary space missions.

The committee deals with component technologies as well as complete propulsion systems and their implementation in missions and spacecraft, but also welcomes discussions on dedicated test facilities and diagnostics for space propulsion testing. Special attention is given to New Space developments, including miniaturized propulsion systems for small spacecraft/launchers, or how combined technologies, such as chemical and electric propulsion, can be optimized for extending the range of feasible space missions.

### Summary - Space Propulsion Highlights

In the **United States**, NASA has scheduled in November 2022 a new attempt to launch the Space Launch System for the Artemis I mission, after two previous attempts were aborted, first due to anomalies during the propellant filling procedures, then due to weather risks. The rocket is powered by four **RS-25D** engines (LOX-LH2) and two five-segments solid rocket boosters, both adapted from the Space Shuttle propulsion system, plus a single RL10B-2 engine for the cryogenic upper stage (LOX-LH2), adapted from the Delta Cryogenic Second Stage used in the Delta III and Delta IV rockets.

In August 2022, SpaceX has completed two important static fire tests within the Starship development program: one **Raptor** engine (LOX-Methane) installed in a prototype

of the 1<sup>st</sup> stage Super Heavy Booster; two Raptor engines installed in a prototype of the 2<sup>nd</sup> stage Starship. The first orbital test of the rocket is expected to happen not earlier than end-2022.

In October 2022 Firefly Aerospace successfully launched its first launch vehicle, which reached orbit. Both stages of the rocket use LOX/RP-1 engines utilizing a tap-off cycle (**Reaver** and **Lightning**), demonstrating the first non-ground and non-suborbital use of tap-off cycle technology up to date.



Starship SN24 fire test with two Raptor engines (court. SpaceX)

In **Europe**, while the maiden flight of the **Ariane 6** launcher is currently postponed to 2023, the first test on the upper-stage **Vinci** engine has been conducted in the P5.2 test bench in DLR Lampoldshausen, in October 2022. Meanwhile, the development of the **ASTRIS** kick stage of Ariane 6 (based on the **BERTA** engine) and of the **Prometheus** engine (LOX-LCH4, 980 kN thrust) are continuing.

The **Vega-C** launcher, based on the **P120-C** solid rocket motor for its first stage and on the **Zefiro 40** solid rocket motor for the second stage, performed a successful maiden flight in July 2022, bringing seven satellites to orbit. In the meanwhile, in May 2022, Avio has performed a successful first hot-firing test of the **M10** engine (LOX-Methane, 10-t class), which will represent one of the key elements of the Vega-E version of the launcher, targeted to fly from 2026.



Fire test of the Vinci engine in October 2022 (court. ESA)

In **Asia**, after a previous failed attempt, South Korea has successfully launched its **Nuri** rocket in June 2022. The first stage of this launcher is powered by four **KRE-075 SL** engines (LOX-Kerosene, 2.9 MN thrust), with the vacuum version of the same engine being used for the upper stage.



Maiden launch of the Nuri rocket (court. KARI)

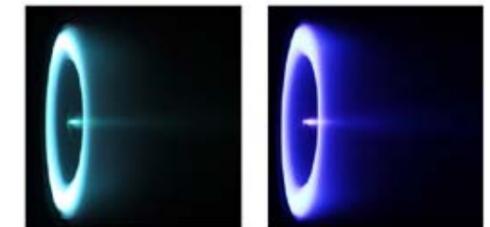
In **China**, the ground test of a LOX-LH2 engine (25 tons thrust) was successfully conducted in September 2022. The engine is designed for the third stage of the planned **Long March 9**, a super heavy-lift rocket intended for space exploration missions, such as crewed lunar landing and exploration on Mars. Still in China, the **ZK-1** solid propellant rocket made its maiden flight in July 2022, successfully sending six satellites into their preset orbits. This four-stages rocket, developed by the Chinese Academy of Sciences (CAS), is intended for launching small to medium-sized satellites (1500 kg total payload into 500 km sun-synchronous orbits).



Test of the LOX-LH2 engine for the 3rd stage of Long March 9

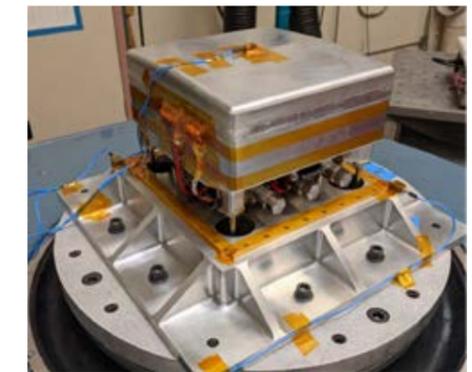
In the **Electric Propulsion** scenario, the crisis due to geopolitical situation is implying a general increase of costs for energy and Xenon propellant. Different European developers are facing these issues and alternative low-cost propellants are being considered. The expected market for EP thruster is continuously growing for different applications and, besides existing leader in Europe and US, new companies from the conventional or the New Space market have started to develop EP products in US, Europe and far-East.

In October, SITAEL (Italy) closed a pre-qualification test campaign of its 5 kW Hall Thruster (HT5k) after the completion of a 1500h endurance test, a full performance characterization in the 3-10 kW power range (both with Xenon and Krypton) and an environmental test campaign (structural and thermal vacuum tests).



HT5k ground tests @SITAEL

Two major milestones have been reached in the **micro-propulsion** scenario, with the successful launch and operations of two beyond-LEO CubeSats equipped with dedicated propulsion systems: the Italian **LICIACube**, which witnessed the impact of the DART spacecraft into the asteroid Dimorphos, carrying a cold-gas micro-propulsion system (50 mN thrust, 40 s specific impulse); and the US **CAPSTONE** mission, currently on its way to the Moon, equipped with eight mono-propellant hydrazine thrusters (3 N thrust) produced by the company Stellar Exploration, implementing a gear pump system for propellant pressurization.



CAPSTONE propulsion system (court. NASA)

### Future Outlook

Very interesting achievements are being reported in the development of low-cost, reliable rocket engines in the

100 kN-thrust class or below for the **micro-launchers** sector. In July 2022, RFA (Germany) has performed a long-duration fire test of the Helix engine (LOX-Kerosene, 100 kN thrust), consisting of three successive burns of 4 s, 30 s and 40 s. Meanwhile, Pangea Aerospace is continuing the development of their ARCOS 300 kN aerospace engine (LOX-Methane).



Fire test of the Helix engine in July 2022 (cour. RFA)

With the aim of industrializing its Electric Propulsion products, SITAEL (Italy) consolidated the adoption of **Additive Manufacturing** techniques for the production of key thruster components, like the cathodes and the anodes (which have a complex internal geometry). AM has been successfully applied to different materials, ranging from stainless steel to alumina, and allowed for a significant reduction of costs and production time.



AM cathode (left) vs. traditionally manufactured cathode (right)

While several large scale suborbital in-flight **hybrid rocket motor** demonstrations shall be postponed till 2023, the South Korean INNOSPACE plans to launch its Test Launch Vehicle "HANBIT-TLV" in December 2022. The single-staged vehicle will use a 150 kN motor utilizing LOX and a paraffin-based fuel. INNOSPACE revealed more details on its planned family of micro-launch-vehicles with electro-pump feeding systems. Hybrid motors with thrust of 150 kN, 60 kN and 30 kN are to be used. Meanwhile, the sister company of the Taiwanese TiSpace, ATSpace in Australia, is planning two launches of its Kestrel hybrid suborbital rocket. The company confirms work on regeneratively-cooled hybrid rocket motors manufactured using copper alloy utilizing an additive process.

In France, the startup company HyPrSpace has per-formed

some firing tests on a hybrid prototype motor, intended as a first step toward a rocket fully powered by hybrid propulsion.



Hybrid prototype motor test (cour. HyPrSpace)

Meanwhile, a recent study from Purdue University researchers (<https://doi.org/10.3390/aerospace9100581>) has assessed the applicability of **Rotating Detonation Combustion** to liquid propellant rocket engines, showing that a 3-14% improvement in specific impulse is theoretically achievable, with especially significant advantages in engines using liquid hydrogen as fuel.

The research vehicle Feitian-1, developed by the Northwest Polytechnical University in China and propelled by a **Rocket-Based Combined Cycle** (RBCC) propulsion system with conventional kerosene-based aviation fuel, has undergone a successful test flight in July 2022. In the first stage of this test flight, an ejector rocket was used to propel the vehicle to the appropriate altitude where the engine could be switched first to ramjet mode and then to scramjet mode, allowing the vehicle to reach hypersonic speed. Finally, a conventional rocket system was used to further raise the altitude.

In the field of **orbital propulsion**, the in-space mobility provider Benchmark Space Systems has been selected by The Exploration Company, a European start-up developing in-orbit exploration vehicles, to develop the propulsion system for its second demonstrator flight ("Mission Possible", set to launch in 2024, with main goal of performing a safe re-entry of the payload capsule). Benchmark and The Exploration Company will collaborate to develop an innovative propulsion system using High-Test Peroxide (HTP), based on Benchmark's Halcyon Avant propulsion system and on the Ocelot 22 N bi-propellant thruster. In-flight demonstration of this propulsion system will be a crucial step towards the maiden flight of Exploration Company's orbital vehicle Nyx Earth, planned in 2026.

### Committee Activities

The committee is currently made of 50 members from 16 countries, including 8 female members and 8 young professionals, with good distribution among geographical areas and categories (industry, Academia, agencies). In

the second half of 2022, two new members have been welcomed in the committee: Marco Di Clemente (Italian Space Agency), William Camilleri (Reaction Engines Ltd).

The committee is not only active in the organization

of the International Astronautical Congress, but also fosters synergies with other relevant space propulsion conferences, such as the EUCASS (European Conference for Aeronautical and Space Sciences) and the biennial 3AF/ESA Space Propulsion conference.

## IAF Space Systems Technical Committee

### Introduction

The Space Systems Committee addresses space systems as a whole from a system concept and system engineering perspective. The Committee's aim is two-fold. Firstly, to focus on the enhancement of system development and reliability, including collection of lessons learned, development of tools, processes and training in the field of systems engineering to further improve the efficiency, risk management, reliability and coordination across disciplines and all the functions necessary to build any space systems. Secondly, to highlight future developments, especially in the fields of innovative and mission-enabling technology, future system architectures and innovative and visionary system concepts.

### Summary

The attendance to the Space Systems Symposium held during the International Astronautical Congress (IAC) 2022 in Paris, France was record high along all the six sessions and the interactive presentations.

### Highlights

The following highlights have been selected among the most significant papers presented in Paris:

- Moon Diver, a JPL mission proposing to investigate the Mare tranquillitatis pit, leveraging pinpoint landing enabled by closed-loop guidance with terrain-relative navigation and robotic access to the pit near-vertical wall with an instrument package to examine the chemistry, mineralogy, and morphology of these bedrock layers (Paper ID: 73136.)
- Oxford Space Systems' innovative origami-inspired X-Band SAR reflect array antenna for small satellites down to 50 kg (Paper ID: 73133.)
- The Development of a workflow to conduct thermal analyses from the open-source MBSE tool Virtual Satellite (VirSat) (Paper ID: 70017.)
- University of Alabama in Huntsville, developed a Mission Planning Ontology with strong semantic relationships connected to mission planning to derive both a mission architecture and process framework



Audrey Berquand at the NextGen Plenary at IAC 2022

- to reduce early workload in project formation (Paper ID: 68782.)
- INPE developed a framework capable of evaluating AIT readiness for complex spatial systems according to the stakeholders' requirements (Paper ID: 68137.)
- The European Space Agency (ESA) and Airbus outlined the process leading to the in-flight update of Solar Orbiter's flight software and the improvement of its fine pointing mode (Paper ID:71074.)
- Caltech/JPL highlighted Galileo probe lessons learned relevant to the design, concept of operation, instrumentation, technologies, and scientific objectives of future Giant Planet entry probe missions (Paper ID:6982.)
- JAXA is currently working to reduce the finite time resource of crew members on the ISS by developing a free-flying robot, Internal Ball Camera (Int-Ball) to conduct photography tasks instead of crews (Paper ID:69912.)
- Uncertainty-aware learned non-parametric dynamics models are used for state estimation filtering and model predictive control with potential applications

in space debris removal and on-orbit assembly and servicing (Paper ID:69089.)

### Future outlook

The committee is currently made of 26 members, including young professionals, and with good distribution among geographical areas (representing 12 countries) and categories (industry, academia and agencies).

The IAF Space Systems Technical Committee is chaired by Jill Prince (NASA). Tibor Balint (JPL) and Reinhold Bertrand (ESA) act as Vice-Chairs.

In Paris, the Committee welcomed two new members:

- Sapna Rao (Lockheed Martin)
- Tim Cichan (Lockheed Martin)

During IAC 2022, Committee member Audrey Berquand participated as panelist at the NextGen Plenary #AI4Space, advocating for Natural Language Processing and Knowledge Graphs applications in the space field.

## IAF Space Traffic Management Committee (STM)

### Introduction

The IAF Space Traffic Management (STM) Committee TC.26 was created to complete the existing Committees dealing with Space Debris, in the general frame of Space Operations Sustainability.

It enables the general overview of the STM topic, synthesizing the work which is performed in numerous other for a, either formal such as Standardization Bodies (IADC, ISO, ECSS, UNCOUOS) or informal such as work done in various Academies, think-tanks, general committees...

TC.26 mainly serves as the organizer of a joint work between IAF (International Astronautical Federation), IAA (International Academy of Astronautics) and IISL (International Institute for Space Law); a joint MOU between these three organizations was signed in October 2018, tasking them to develop comprehensive approaches and proposals for STM to be addressed to decision makers.

### Summary

The TC.26 is structured following several steps.

The first phase consisted in 9 thematic Working Groups; the corresponding findings were presented at IAC 21 in Dubai during a dedicated Special Session.

Since this event, the second phase has dealt with 5 additional thematic Working Groups

Some 137 experts did participate to these Working Groups; they were fully compliant to the IAF 3G motto, Generation with numerous of Young Professionals, mainly from SGAC, Gender with a high percentage of women, Geography with 24 different countries all over the world.

Each Working Group was chaired by two coordinators coming again from everywhere in the world, including China, India, Russia, ...

The second phase was finished shortly before the IAC 2022 in Paris

The results were presented during a dedicated Special Session on 17 September where the final outcome of the two first phases were presented.

The corresponding Executive Summary Report prepared jointly between IAF, IAA and IISL was handed to the three Presidents who signed it in real time at the end of the Special Session (Pascale Ehrenfreund, Kai-Uwe Schrogl, John Schumacher).

Each Working Group also prepared a 10 pages report in addition to its executive summary; the compilation of these reports will be published in a dedicated Special

Issue of Acta Astronautica, tentatively by the end of 2022.

### Highlights

The main highlights concerning TC.26 on STM for the past year are the finalization of the 14 Working Groups, with the publication of the corresponding Executive Summary, signed by the 3 Presidents (IAF, IISL, IAA) at the end of the Special Session on 17 September.

### Future Outlook

The upcoming activities follow 3 axes:

Numerous participants to the two first phases suggested to continue on some of the 14 first topics, in order to go deeper in the work and complete what was done so far.

A set of four new Working Groups are currently under definition, with an open call for qualified volunteers.

New topics are under maturation for additional proposals.

The next meeting of the IAF STM Committee will take place during the IAF Spring Meetings in March 2023, and a "Draft Final" status of the activities defined here will be done during the meeting foreseen just before IAC 2023.

### Committee activities

The Committee holds two formal meetings per year, during the IAF Spring Meetings, and just before the regular IAC. However, each Working Group has its own agenda and meets whenever necessary, usually once per month.

## IAF Space Transportation Committee

### Introduction

The objective of the IAF Space Transportation Committee 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 and lessons learned
- To build a world-wide network of communication and relationships
- To encourage, promote, and assist the development of newer members of the space community through 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 committee organizes the D2 space transportation symposium during the yearly International Astronautical Congress including following technical sessions: Launch Vehicles in Service or in Development, Launch Services, Missions, Operations, and Facilities + Upper Stages, Space Transfer, Entry & Landing Systems + Future Space Transportation Systems + Small Launchers + Space Transportation Systems for Deep Space Missions and on Emerging Space Ventures, including Space Logistics and Space Safety for Sustainability.

### Summary

One of the major highlights in 2022 is once again linked to the achievements in commercial human space transportation with the continuation of successful flights of Blue Origin and SpaceX.

On 31 March 2022, Blue Origin's New Shepard vehicle performed its fourth crewed suborbital spaceflight with six passengers on board. On 4 June 2022, New Shepard performed its fifth crewed suborbital spaceflight, also with six passengers on board. On 4 August 2022, New Shepard performed its sixth crewed suborbital spaceflight, again with six passengers on board.

On 8 April 2022, SpaceX's Crew Dragon space capsule was launched by a Falcon 9 rocket for the first American space tourist mission to the International Space Station. The crew on board the Axiom Space-operated mission included one professional astronaut (space vehicle commander) and three tourists. The mission, known as Axiom Mission 1, lasted a little over 17 days and was the first wholly commercially operated crewed mission to the ISS.

Further there is a good deal of growth currently in small startups and new launch vehicle developers in the United States in particular, but in the world as well. Some companies are focusing on more agile launchers that can be launched from novel locations, some are focusing on smaller launchers for smaller satellites, some are focusing on new technologies such as additive manufacturing, and others are attempting to use novel materials or new technologies to break into the market.

Additionally, the major players are working to extend booster reusability (multiple companies working on this right now) as well as significant improvements in up mass capability. In general the launch vehicle space is in a period of very high innovation.

Regarding the Brazilian space sector and related advances in space transportation technology and launch operations, it can be understood that Brazil is in a moment of transition. The Brazilian space program, although traditional in its inception, is now adapting to include a larger participation of the private sector in technology development and to begin our commercial launch activities from the Alcântara Space Center (CEA).

This perspective brings new challenges, such as the technology transfer from the public institutes to the industry and the creation of a new legal framework that can usher the beginning of orbital launches from Brazil.

AEB published the Regulations for Licensing of Space Activities Operator and for Launch Authorization in Brazilian territory. This initiative is important because the regulations are similar to those already adopted by the FAA. The idea is to make it easier and faster to issue licenses for companies that already have an FAA license or have already started the process in the United States.

## Highlights

### ITALY

Italy is pursuing the follow up activities to setup and outfit the airport of Grottaglie designated by the Italian Government as future spaceport for suborbital flights and national strategic infrastructure; interactions are on-going to attract operators of new technology for access to space.

Italy has heavy involvement in the ESA Space Rider project, an automated space vehicle, which can be reused for unmanned re-entry. Leveraging on the heritage of the IXV mission and on the experience gathered in the frame of ISS and data processing activities, ALTEC supports the missions of Space Rider encompassing the roles of Payload and Landing Control Center. ALTEC is the gateway for all Payloads onboard Space Rider, guaranteeing a safe return and landing of the spacecraft and its cargo.

### BRAZIL

For the past years, Brazilian Space Program (PEB) has advanced on filling the technological gaps that are present on our path to national access to space. The recent testing of the largest Solid Rocket Motor (SRM) up to date, the S-50, has sparked needed interest in the full development of the Micro Launch Vehicle VLM and other parallel roadmaps. The S-50 is a successful case for technology transfer from the institutes to the industry, as it is developed in tandem between the Institute of Aeronautics and Space (IAE) and partners from the industry. Another

recent success case was the launch of the first privately built VSB-30 rocket, our most successful sounding rocket, transferred to the industry and previously offered by the government (IAE).

Although traditionally the PEB has focused on SRM for rocket development, the national private sector has shown great interest in Liquid and Hybrid Rocket Engines. A study on the topic was published by committee member Danilo Sakay on the D2.4 session of the 73<sup>rd</sup> IAC (IAC-22,D2,4,4,x70089). The government has recently opened a public call for Nano Launch Vehicles, as a first step to stimulate the industry with the challenge of orbit insertion with a new launch vehicle prototype.

Brazil is working to transform the Alcântara Space Center into a commercial center for space activities. The AEB made two public calls for companies interested in operating in the center. Two companies have already signed contracts to use the center.

### UNITED STATES OF AMERICA

Rocketlab's small reusable launcher Electron was captured via a "catch" in May of 2022. Many other vehicles are in development of landing technologies to continue to improve the reusability of launch vehicles. SpaceX has demonstrated 14 flights on a single Falcon 9 booster.

On the large launcher front, SpaceX is testing the largest launch vehicle ever built with the intent of becoming the first vehicle with a reusable first and second stage, contracted with NASA to send payload and passengers to the moon. NASA's SLS launcher is nearing readiness for its first flight, and Blue Origin is also working on their first launch of New Glenn which will bring another heavy launch vehicle to the market as well.

SpaceX, Blue Origin, and Virgin Orbit continue to fly private astronauts to low earth orbit and the edge of space, commercializing space travel in a way that is unprecedented and has potential to change the market for human spaceflight substantially.

SpaceX has also flown its Falcon 9 rocket 48 times this year to date, holding the record number of launches for any launch vehicle in a given year and is on track to hit an average of one launch per week this year. This highlights the commercialization of space and indicates that more commercial mass is getting to orbit than ever before.

NASA has scheduled a new attempt to launch the Space Launch System for the Artemis I mission for November 14, after two previous attempts were aborted, first due to anomalies during the propellant filling procedures, then due to weather risks.

In October 2022 Firefly Aerospace successfully launched its first launch vehicle, which reached orbit.

### EUROPE

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The Vega-C launcher, based on the P120-C solid rocket motor for its first stage and on the Zefiro 40 solid rocket motor for the second stage, performed a successful maiden flight in July 2022, bringing seven satellites to orbit.

In-space mobility provider Benchmark Space Systems has been selected by The Exploration Company, a European start-up developing in-orbit exploration vehicles, to develop the propulsion system for its second demonstrator flight ('Mission Possible') which is set to launch in 2024. Benchmark and The Exploration Company will work together to develop an innovative propulsion system that will utilize non-toxic high-test peroxide propellant. The system will be based on Benchmark's flight-proven Halcyon Avant propulsion system, featuring Benchmark's 22N "Ocelot" bi-propellant (HTP + IPA) thrusters. The Exploration Company has scheduled the launch of its demonstration Mission Possible for 2024, with the main objective being to perform a safe re-entry of the capsule that will host payloads from first customers. Moreover, the target is to perform a safe splash-down in the ocean, including recovery. As a final objective, The Exploration Company looks forward to the demonstration of its propulsion capabilities during orbital flight, as well as during re-entry, using the aforementioned propulsion system in preparation of the planned maiden flight of The Exploration Company's orbital vehicle Nyx Earth, that will take place in 2026.

### ASIA

South Korea has successfully launched its Nuri rocket in June 2022. The launcher is powered by LOX – Kerosene engines.

The ZK-1 solid propellant rocket made its maiden flight on July 27. This rocket was developed by the Chinese Academy of Sciences (CAS). It has the 2.65 meter in diameter and 30 meter in length. The ZK-1 is capable of sending payloads of 1,500 kilograms into 500-kilometer Sun-synchronous orbits (SSO).

## Future Outlook

SLS is at the launch pad now and will bring a high mass capability launcher back to NASA for lunar exploration missions and high payload science missions.

Next year should see first flights of Starship and New Glenn, ushering in cutting edge vehicles that have up to 100t lift capability with reusability in mind.

On the small launcher front, competition is expected to

drive cost down and access to space up for small payloads as these companies compete for launch contracts and bring in new previously undeveloped markets for launchers.

The global demand for private astronauts as well as the increased number of providers is expected to bring a larger and larger number of people to travel to and work in space. With the lofty goals of NASA's Artemis mission and the combined vehicles of SLS and Starship, return to the Moon and exploration of Mars are more real than they have been since the 1960s. With the capability that these vehicles bring and the improvement in operational cadence being demonstrated, large amounts of payload could be delivered to these locations, enabling more permanent human presence, such as a lunar and mars base.

In near future, Brazil can offer access to space, either through the commercial services of international companies operating at CEA or by our own means, with the VLM or new small launch vehicles for dedicated missions.

The parallel activities of commercial launches and launch vehicle development will hopefully engage the Brazilian ecosystem towards a stable stage of production and evolution, where the national industrial park is kept active by a multiple projects and growing demand for launches.

Brazil is working in a few studies for 2023:

- Space regulations as instruments of competitiveness of launch countries
- Public financing instruments for space investment in Brazil
- The financing model for research and development activities in the Brazilian space sector

The following important maiden flights are planned:

- H3 – JAXA – Japan
- Space Launch System – NASA – USA
- Starship – SpaceX – USA
- Spectrum (de) – Isar Aerospace – Germany
- RFA One – RFA – Germany
- Prime – Orbex – Scotland
- C6 Launch Systems – Canada
- Terran 1 – Relativity Space – USA

## Committee activities

The Space Transportation Committee will continue the organization of virtual meetings / webinars in between the IACs and the spring meetings. The 3<sup>rd</sup> webinar is scheduled for December 2022. Also, after the successful special session in frame of the IAC 2022, it is discussed within the committee, if another special session, plenary or GNF should be proposed by the committee w.r.t. IAC 2023 in Baku. Especially as new space transportation systems will be launched soon for the first time like SLS and Starship. Then it is in discussion within the committee, if and how social media could be used in order to promote the committee activities. Finally fostering synergies with other relevant space conferences are checked.



# 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 468 members from 75 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

## The IAF Secretariat



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.

## 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 Alliance Programme is open to all IAF Members and aims to deepen the involvement of IAF Members in the Federation, enhance the prominence and visibility of their role within the Federation, complement the traditional sponsorship opportunities with strategic long-term partnerships, assure the sustainability of IAF operations in the interest of its Members; further improve the quality of the Federation's activities, and strengthen the Federation by fortifying the one-to-one relationships with its Members.

IAF Alliance partners are guaranteed enhanced visibility on IAF promotional tools, enhanced presence at IAF Events, and the possibility to launch innovative projects!

Become an IAF Alliance Partner! Contact us at [info@iafastro.org](mailto:info@iafastro.org)



## IAF Alliance Programme Partners:



# IAF EVENTS 2023

*Connecting @ll Space People*



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