



**INTERNATIONAL
ASTRONAUTICAL
FEDERATION**

IAF HIGHLIGHTS

2019



Connecting @ll Space People

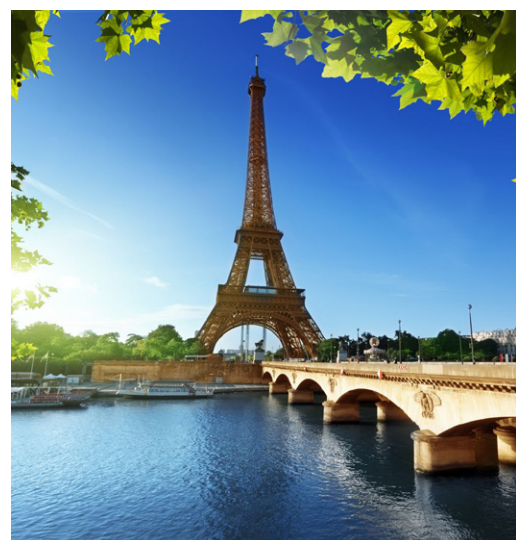
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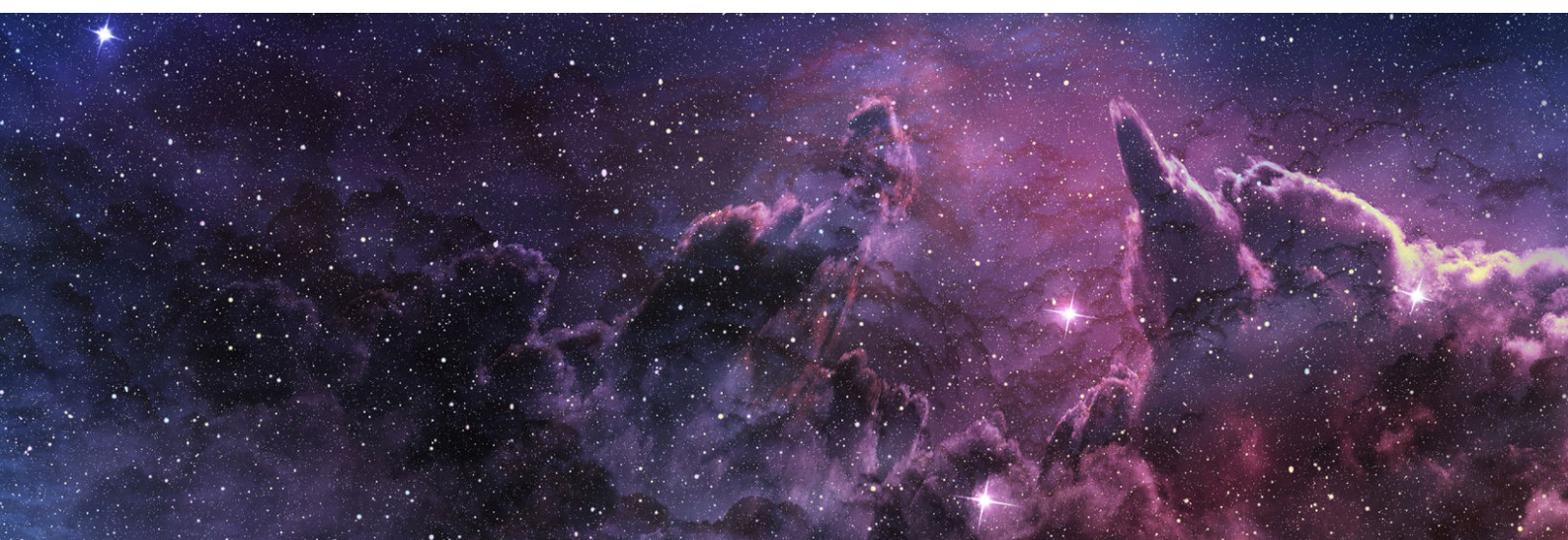
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Abbreviations

ADR	Active Debris Removal	ISZ	International Student Zone
AEB	Brazilian Space Agency	ITACCUS	IAF Committee for the Cultural Utilisation of Space
AIAA	American Institute of Aeronautics and Astronautics	JAXA	Japan Aerospace Exploration Agency
ASI	Italian Space Agency	JPL	Jet Propulsion Laboratory
BEC	Bose-Einstein Condensate	LEAP	Lunar Exploration Accelerator Programme
CLPS	Commercial Lunar Payload Services	LTS	Long Term Sustainability
CNES	Centre National d'Études Spatiales	MARSIS	Mars Advanced Radar for Subsurface and Ionosphere Sounding
CONFERS	Consortium for Execution of Rendezvous and Servicing Operations	MBRSC	Mohammed Bin Rashid Space Centre
CRTS	The Royal Centre for Remote Sensin	MEV	Mission Extension Vehicle
CSA	Canadian Space Agency	MoP	Members of Parliament
EDRS	European Data Relay System	MS	Member States
EEAS	European External Action Service	NASA	National Aeronautics and Space Administration
ELSA-d	End-of-Life Services by Astroscale-demonstration	NEO	Near-Earth Objects
EOL	End of Life	NEOSM	Near-Earth Object Surveillance Mission
ERMC	IAF Enterprise Risk Management Committee	NESDIS	National Environmental Satellite, Data, and Information Service
ESA	European Space Agency	NOAA	US National Oceanic and Atmospheric Administration
EU	European Union	NRHO	Near Rectilinear Halo Orbits
FAA	Federal Aviation Administration	OSAM	On-Orbit Servicing, Assembly, and Manufacturing
GEO	Group on Earth Observations	PDC	Planetary Defense Conference
GEOSS	Global Earth Observation System of System	PNT	Positioning/Navigation/Timing
GGPEN	Angola's National Space Programme Management Office	PPP	Public-Private-Partnership
GISTDA	Geo-Informatics and Space Technology Development Agency	PRS	Public Regulated Service
GLEC	IAF Global Conference on Space for Emerging Countries	ROSCOSMOS	Roscosmos State Corporation for Space Activities
GLEX	IAF Global Space Exploration Conference	RPO	Rendezvous and Proximity Operations
GNSS	Global Navigation Satellite System	SANSA	South African National Space Agency
Govsatcom	Governmental Satellite Communications	SEOC	IAF Space Education and Outreach Committee
GRSCE-FO	Gravity Recovery and Climate Change Experiment Follow-on	SGAC	Space Generation Advisory Council
GSFC	NASA's Goddard Space Flight Center	SLS	Space Launch System
GTOC	Global Trajectory Optimization Competition	SST	Space Surveillance and Tracking
HAC	IAF Honours and Awards Committee	STC	IAF Space Transportation Committee
IAC	International Astronautical Congress	STM	Space Traffic Management
IAF	International Astronautical Federation	TC	Technical Committee
IAF GNF	IAF Global Networking Forum	ToR	Terms of Reference
IAWN	International Asteroid Warning Network	UAE	United Arab Emirates
ICAO	International Civil Aviation Organisation	UAESA	UAE Space Agency
IDEA	International Platform for Diversity, Equality and Astronautics	UCLA	University of California, Los Angeles
IISL	International Institute of Space Law	UNCOPUOS	United Nations Committee on the Peaceful Uses of Outer Space
IRC	IAF Industry Relations Committee	UNOOSA	United Nations Office for Outer Space Affairs
ISEB	International Space Education Board	USA	United States of America
ISF	International Space Forum	WD-YPP	IAF Workforce Development-Young Professionals Programme Committee
ISRO	Indian Space Research Organization	WoAA	Women of Aeronautics and Astronautics
ISS	International Space Station		
ISU	International Space University		

Welcome Message



It has truly been an exciting year for the International Astronautical Federation in 2019. This publication, the IAF Highlights, is summarizing the main IAF events and activities that took place during 2019 including: SM in Paris, GLEC in Marrakech, ISF in Reggio Calabria and IAC in Washington D.C.

Following on IAC 19's theme, *Space: The Power of the Past, the Promise of the Future*, this has been a year to look into the past and to recognize all of our achievements. Important celebrations have taken place with the 50th anniversary of Apollo 11 and the 70th anniversary of the IAC. But it has equally proven to be a year to look towards the future and the new impressive accomplishments we will be able to achieve together.

An important focus in 2019 has been on the development of space capabilities in Emerging Space Nations. For the first time IAF organized a Global Conference just dedicated to this mission, GLEC 2019, the Global Conference on Space for Emerging Countries. It took place in Marrakech, Morocco and was organized in partnership with the Centre Royal de Télédétection Spatiale (CRTS) and the Centre National d'Études Spatiales (CNES).

The 70th International Astronautical Congress was hosted by the American Institute of Aeronautics and Astronautics (AIAA) in Washington D.C., United States. This was an extraordinary week with more than 6600 delegates from 80 countries! The Opening Ceremony included the presence of US Vice President, Mike Pence, who welcomed the IAC 2019 delegates. Apollo 11 Crew/family members; Buzz Aldrin, the grandson of Michael Collins, and the son of Commander Neil Armstrong, all attended the ceremony to receive the IAF World Space Award in recognition of the Apollo mission. We also had the pleasure to hand out the IAF Excellence in Industry award to the inspiring founder of Blue Origin, Jeff Bezos.

Now we begin a new chapter, it is a true honour for me to have taken over the IAF presidency from Jean-Yves Le Gall who have done an outstanding work with the Federation and I look forward to continue his efforts and develop new activities with the IAF Bureau and the entire IAF family. This year new exciting challenges and events lie ahead. IAC 2020 will represent a milestone for the Federation as well as for the United Arab Emirates, as it will be the very first time that it opens its doors to an Arabic country.

Finally, I would like to wish you all the best for a successful 2020 and I am looking forward to be working with all of you to create a new wonderful year full of Space!

Pascale Ehrenfreund
President,
International Astronautical Federation (IAF)

Editor's note: At the end of the IAC 2019, Pascale Ehrenfreund took over as the new President of the International Astronautical Federation (IAF), following Jean-Yves Le Gall who served as the IAF President September 2016 - October 2019.

IAF 2019

Events Overview



IAF 2019 General Assembly Report

The International Astronautical Federation General Assembly has gathered during the International Astronautical Congress, IAC 2019 in Washington, D.C., United States in two sessions (Monday, 21 October 2019, and Friday, 25 October 2019). Several important decisions have been taken.



2019 Elections of IAF Officers

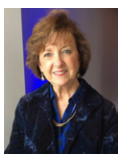
Four new Vice-Presidents have been elected by the General Assembly:



Deganit PAIKOWSKY, Lecturer, Graduate programme for Security and Diplomacy Studies, Tel Aviv University, has been appointed as IAF VP for Diversity Initiatives and New Space Economy;



Sergey SAVELIEV, Deputy Director General for International Cooperation, State Space Corporation "ROSCOSMOS", has been appointed as IAF VP for Relations with International Organizations;



Mary SNITCH, Senior Staff, Global S&T Organizations, Lockheed Martin, has been appointed as IAF VP for Communications, Publications and Global Conferences;



Dominique TILMANS, President, EURISY and Honorary Senator, has been appointed as IAF VP for Parliamentarian and Ministerial Relations and User Communities.

Selection of Host City for IAC 2022

The IAF General Assembly at its second session on 25 October 2019, selected Baku, Azerbaijan, as Host City for IAC 2022. The Hosting Organization is Azercosmos, a member of IAF since 2018.

Upcoming IAF Events Reports

During the IAF General Assembly sessions, reports were given on the advancement of preparation for the IAC 2020 in Dubai, United Arab Emirates and for the IAC 2021 in Paris, France.

Also, a detailed presentation was offered on the progress made in the organization of the Global Space Exploration Conference 2020 (GLEXP 2020) to be held in St. Petersburg, Russian Federation, on 09-11 June 2020 in cooperation with the State Space Corporation "ROSCOSMOS".



IAF Finance

The IAF General Assembly has also approved the **Final Accounts 2018 and Auditor's Statement 2018**, the **Revised Budget and Preliminary Accounts 2019** and the **Proposed Budget 2020**.

New IAF Members

The IAF General Assembly also approved the applications of 41 new Member Organizations. With this, the IAF Membership comprises 397 Member Organizations from 68 countries, confirming IAF's position as a truly global Federation.

The New IAF Members are:

Company	Category	Region	Country
Aerospace Industries Association	Association	North America	United States
Beijing Infinite Education Inc.	Space Industry	Asia	China
Beijing Interstellar Glory Space Technology Co., Ltd	Space Industry	Asia	China
Beijing Smart Satellite Technology Co., Ltd.	Space Industry	Asia	China
Berkeley SETI Research Center	University	North America	United States
Canadensys Aerospace Corporation	Space Industry	North America	Canada
Colegio Federado de Ingenieros y de Arquitectos de Costa Rica (CFIA)	Association	Latin America	Costa Rica
Council of European Aerospace Societies (CEAS)	Association	Europe	Belgium
Dereum Labs S.A. de C.V.	Space Industry	Latin America	Mexico
Digantara Research and Technologies Private Limited	Space Industry	Asia	India
Disrupting Space LLC	Space Industry	North America	United States
D-Orbit SpA	Space Industry	Europe	Italy
Dynetics	Space Industry	North America	United States
EnduroSat AD	Space Industry	Europe	Bulgaria
Hong Kong Aerospace Technology Group	Space Industry	Asia	China
Institute for Q-shu Pioneer of Space, Inc. (iQPS)	Space Industry	Asia	Japan
Khalifa University of Science and Technology	University	Asia	United Arab Emirates
Lithuanian Museum of Ethnocosmology	Space Museums	Europe	Lithuania
Luxembourg Space Agency (LSA)	Space Agency	Europe	Luxembourg
Massachusetts Institute of Technology	University	North America	United States
Nanjing University of Aeronautics and Astronautics	University	Asia	China
Nanoracks	Space Industry	North America	United States
National Astronomical Research Institute of Thailand (NARIT)	Research and Development	Asia	Thailand
National Autonomous University of Honduras	University	Latin America	Honduras
National Institute of Aerospace (NIA)	Research and Development	North America	United States
National Space Society	Association	North America	United States
Northwestern Polytechnical University	University	Asia	China
Open Cosmos	Space Industry	Europe	United Kingdom
Qwaltec Inc.	Space Industry	North America	United States
Satellogic Solutions S.L.	Space Industry	Europe	Spain
SIDERALIS Foundation	Association	Latin America	Ecuador
Singapore Technologies Engineering Limited	Space Industry	Asia	Singapore
Space Applications Services NV/SA	Space Industry	Europe	Belgium
Spacebit Global Ltd	Space Industry	Europe	United Kingdom
SpaceBuzz	Association	Europe	The Netherlands
SpaceChain Foundation Ltd.	Space Industry	Asia	Singapore
Technical University of Košice	University	Europe	Slovak Republic
The National Space Science and Technology Center (NSSTC)	Research and Development	Asia	United Arab Emirates
ThrustMe	Space Industry	Europe	France
United Launch Alliance LLC	Space Industry	North America	United States
University Mediterranea of Reggio Calabria	University	Europe	Italy

IAF Spring Meetings 2019



27-29 March 2019 | Paris, France

From the 27 - 29 March the IAF community gathered in Paris for the traditional Spring Meetings. Three days filled with committee meetings, two bureau meetings, events and discussions.



The IAF Spring Meetings started off on Tuesday morning with the Diversity Day. Jean-Yves Le Gall, IAF President, informed that the International Astronautical Federation has received an increased number of members from emerging countries. A keynote was held by Ana Aanesland, Founder & CEO, ThrustMe, from Norway. Ana talked about her experiences with diversity and how it affected her growing up in a small fishing village in the north of Norway.

She explained that diversity is important because it increases the productivity in a company, but she also emphasized that it can be challenging to strive for since you have to get out of your comfort zone, as it is much more difficult to work with someone very different than yourself.

Thereafter roundtable discussions were followed on important questions concerning space industry careers. The tables were mixed to include both prominent space industry leaders and young generation delegates to provide valuable mentoring.

During the IDEA Lunch event the focus was on Geographical Diversity. Valanathan Munsami, GLEC 2019 Co-Chair, explained that it is important to understand the challenges emerging countries are facing. He followed by presenting the detailed programme of the Global Conference on Emerging Countries (GLEC 2019) Marrakech, Morocco.

Wednesday started with a IAF GNF session that reported on the results from **Italian Space Forum (ISF 2018) in Buenos Aires – The Latin American and Caribbean Chapter**. This was followed by the session **Welcome (back) to Space: An Overview of SS2's Historic Spaceflights**. It was presented by Stephen Attenborough, Commercial Director of Virgin Galactic. He discussed Virgin Galactic's interesting journey and plans towards becoming the world's first commercial space line.

In the afternoon four other IAF GNF Sessions were held, the first one was **ISS and Beyond: Commercialisation, Privatisation and Global Collaboration**. Jan Woerner, Director General at the European Space Agency, led the interesting high level panel discussing how we can move forward to evolve and create something even greater than the International Space Station in the future. The IAF GNF Session **An Overview of the Mission of Chang'e 4 Lunar Probe** explained in great detail both the significance and the challenges of the mission which was the first one to land on the far side of the Moon. **Moon Village Association: Preparing a Solid Ground for the Moon Village** gave a thorough presentation of the Moon Village Association's activities. Their aim is to use the Moon in



a sustainable and peaceful manner to the benefit for the whole humanity, and they work to foster the implementation of a moon village. The last IAF GNF Session was **Baku – Candidate City from Azercosmos to Host 73rd IAC in 2022**. In this session the audience got the opportunity to be familiarized with one of the candidates for IAC 2022, Azercosmos in Baku.

As usual, the Wednesday was finished with the annual IAF Cocktail Reception.

Thursday and the final day of the IAF Spring Meetings was dedicated to the Abstract Selection for IAC 2019. It started off in the morning with the IPC General Meeting followed by the IAF Distinguished Service Awards Ceremony and thereafter the IAC 2019 Abstract Selection commenced. The IPC members had a very challenging task to select from a record number of 4330 submitted abstracts.

The whole Spring Meetings finished with a press conference by Jean-Yves Le Gall, IAF President.

“Diversity is important because it increases the productivity in a company”

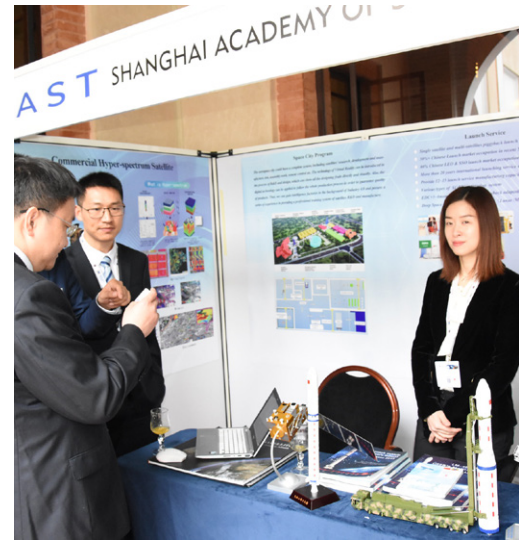




GLEC2019
GLOBAL CONFERENCE
ON SPACE FOR
EMERGING COUNTRIES

IAF Global Conference on Space for Emerging Countries

24-26 April 2019 | Marrakech, Morocco



The first Conference of its kind, the IAF Global Conference on Space for Emerging Countries (GLEC 2019), was held by the IAF, in partnership with the The Royal Centre for Remote Sensing (CRTS) and the Centre National d'Études Spatiales (CNES), in Marrakech, Morocco, between 24 and 26 April 2019. As part of the Conference, a half-day seminar was also organized in cooperation with the Space Generation Advisory Council (SGAC). The Conference was a great success and attended by more than 400 participants from 20 different countries.

The Conference programme was designed to bring together the international community, including senior representatives of the space agencies, industry, governments, policy makers, academia and NGOs. Leaders in these various fields converged in Marrakech to present results, exchange ideas, debate roadmaps, and discuss the future opportunities provided by space activities to emerging countries. The comprehensive programme included high-level keynotes and round tables focusing on the following thematic Sessions:

1. **Benefits of Space Technology and Applications to Socio-Economic Development,**
2. **Financial Models and Resourcing,**
3. **Technology and Skills Development,**
4. **Base Infrastructure Requirements,**
5. **Space Industry Development and Support, and**
6. **Legal and Policy.**

Session 1 – Part 1 (Agency Perspective) Benefits of Space Technology and Applications to Socio-Economic Development

Engage in a dialogue with government to make sure that the Agency's policy is in line with what government really wants by providing a full range of products and services, taking full benefit of a comprehensive space programme in all fields (including human spaceflights) and taking advantage of multidisciplinary approaches. Ensure that national prestige considerations do not divert the national investment which should, on the contrary, present a high value for money. When promoting active international cooperation amongst space actors from different spheres it is important to ensure a win/win approach that shares the benefits of space. In this respect, make sure to maximize the benefits of cooperation, be it regional, international, inter agencies or with the industry to increase the efficiency and effectiveness of national policies. We should also be giving hope to the youth by investing in inspiring missions and encouraging the young generation to embrace a career in STEM so that we prepare and encourage the young generation to take over from the many space engineers and scientists that will retire in the years to come.



Session 1 – Part 2 (Industry Perspective) Benefits of Space Technology and Applications to Socio-Economic Development

The rationale for the commercial space industry using public private partnerships in the USA was (i) to provide services for the International Space Station (ISS), (ii) to transport astronauts to the ISS using commercial launch vehicles, and (iii) promote broader international partnerships on the ISS. Emerging countries should focus on downstream space applications. The SDGs is a call to arms for the space sector to assist in tackling global challenges. Developed countries actually need developing countries, as there is a barrier to entry of new technologies in developed countries, which is not the case in developing countries. Stress was also placed on telecommunications and the use of public funds to invest on critical space infrastructure. Telecommunications allows for penetration in remote areas and businesses working from remote areas. Earth observation and navigation are the other areas of importance for space applications. Governments should focus on enabling the local ecosystems to respond to these opportunities. Assessments of the economic impact of investments in the space sector and how to focus investments in the sector to maximize the returns on investment have helped to motivate the case of investments in the space sector.

Session 2 Financial Models and Resourcing

If we examine every nation's spend on space-based innovation and technology, we would be surprised that we are already spending what we are scared of spending as direct investment. It is necessary to reflect on our daily consumptions that are enabled by space to understand the benefits, so we can be able to communicate these benefits in terms of the economy and improvements of quality of lives of citizens to policy makers in order to get the necessary investment. It is important to understand "the why" before "the how." And space science needs to be incorporated into a country's economic growth plan and goals, and needs a smart investment strategy to have a positive return—build the ecosystem and unlock the potential. There is funding out there through excess liquidity. Beyond the technology,



other aspects are driving the investment such as risk profiles and lead times. It is important to understand who the stakeholders are and the purpose the project will serve. Each country should evaluate for itself how activities leverages the Sustainable Development Goals, the financial mega trends, and the required space capabilities. If a country has good governance and appropriate capacities in place, financing should not be a problem because there is money available through a blended mix of models using terrestrial financing schemes. One such model is government-to-government partnership, with projects funded by the government. For example, small satellites are an approach that is suitable for government cooperation, particularly for solving challenges like climate change.

Session 3 Technology and Skills Development

We should emphasize the important role of academia in educating, training and helping the researchers to improve their capabilities and build their knowledge, as well as supervising their work by the experts and space leaders and ensure the continuing learning process since space is a very dynamic field. The space application should be used for the education and involvement of the young engineers that are coming from different fields into the space domain. We should encourage local universities from developing countries to participate in international projects and events. Government should play a big role in establishing national plans to address the needs of the country in terms of applications and the utilization of data; effectively bringing space down to earth. Companies should support the space programme by training the skilled resources and investing more in the space market and facilitating international collaboration. Space faring countries should support the emerging countries by enhancing the cooperation and sharing the know-how and show the successful models of well-established business and cooperation. UNOOSA, space agencies and organizations have to support the emerging countries by offering fellowship programmes to students in order to learn and have experience. Partnerships with private entities should be enhanced in a way to encourage the investors to enlarge the space market.



Session 4 Base Infrastructure Requirements

Focus should be on 1) identifying the base infrastructure required for operationalizing efficient and effective national space programmes and 2) appreciating how to develop the appropriate skills and expertise required for the efficient operations of space infrastructure. We should recognise the importance of international cooperation and partnerships to support those activities. A new space agency should be seen as a vehicle that focuses on the application of data that contributes to better life on Earth and should therefore have a clear objective, which recognises the importance of human capital and knowledge transfer. In this regard emerging space nations need to build domestic support first before looking internationally so that universities can contribute to such national space efforts. Data should be viewed as the main infrastructure consideration and the need for easier access, and space infrastructure should be viewed as critical rather than optional and the importance of building a well-trained workforce should be viewed in the context of operating such critical infrastructure. Earth observations creates a potential for information and better decision-making, but requires the need for open processes for data and analysis.

Session 5 Space Industry Development and Support

Several drivers are linked to funding and investment such as through Public-Private-Partnership (PPP), and where venture capital are key drivers in industry development. Sustainable national space programme development, capacity building, direct contribution to economy are considered as significant drivers. National space policy should aim at defining priorities for a national space programme, creating a conducive and transparent environment for investment and defining industry frameworks. The most necessary means for the government to encourage the development of local industry is to provide a favourable regime in tax revenue and implement share investment between government and industry. Multinational and international governmental

projects are also important. The following criteria are considered as successful criteria for a technology transfer programme: skills and experience staff, sustainability and independence in the future are the return on experience. Technology transfer can also be a spin off for space technologies into non-space sectors, such as the case with the Business Incubation Center model.

Session 6 Legal and Policy

Given the sensitive nature of space activities, especially with respect to (i) dual use technologies, (ii) the United Nations treaties and conventions, and (iii) national space law that is needed to govern the peaceful use of outer space, legal and policy considerations must be given to these important factors. Emerging countries are not necessarily familiar with this domain and these can easily be ignored in the establishment phase of national space programmes. The current United Nations Treaties, and Principles that govern global space activities need to be considered by emerging space nations as they develop national space policies and legislation, and the current challenges relating to their national interpretation. There is a need to ensure space law is integrated into the university curriculum so that we ensure the sustainability of space activities as the national programme is further developed. There is also a need to ensure consistency with respect to space law on a national basis and a common understanding of both legal and policy considerations across the States associated with a regional agency which could be a challenge. It is essential for any nation developing a new space programme to identify its main objectives and to differentiate that country's situation from others and to build awareness within the country in relation to the benefits of a space programme, to develop a whole-of-government approach,

and to ensure that the programme reaches out to the population as a whole. We are currently in a time of change with respect to space activities with new actors, new activities, new concerns and new tensions; including space sustainability, debris mitigation and space traffic management. There is a need for strong, clear, top-down leadership from the government and to learn from the successes and challenges that have arisen in the development of other nation's space frameworks.

Next Generation Seminar

The seminar aimed at engaging emerging countries' youth providing them the opportunity to discuss and give their views on space applications. Quoting Dr. El Hadani, the Director General of the The Royal Centre for Remote Sensing (CRTS) "the youth is the future of every nation and the future inheritors of the earth tomorrow", that is the reason why we should enhance their contribution and implication following 3 key elements:

1. Research and development
2. Entrepreneurship and its impact on social as well as cultural and economic progress and the fact that the government should support the young entrepreneurs
3. Inspiring young students: by outreach programmes.

According to Khatri, Executive Director - Space Programme of the South African National Space Agency, these points constitute the basis for the development of the ecosystem of space. They bridge the ethnic and gender gaps, spark the interest in pursuing STEM education and careers as well as allow for a healthy competition in the global space economy.





Inspiring young students is particularly important for emerging space nations. Dr. Mohamed Nasser Al Ahabbi, Director General of the UAE Space Agency, said: “Many young people in our region are confused, they are hopeless about the future. So, we have to inspire them. Our space programme is largely driven by this wish to inspire”. Nations need to have space programme that inspire the next generation. Mr. Al Rais, Manager, Business Development and External Relations, Deputy Project Manager of UAE Mars Mission, Mohammed Bin Rashid Space Centre (MBRSC) spoke about how the United Arab Emirates is proceeding for sustaining their space programme. According to him, focusing on and trusting the human element is very important, as well as developing technologies and focusing on international collaborations.

The Special guest of the Seminar was the former Administrator of NASA Charles F. Bolden Jr., with whom the Keynote Speech Moderator, Ms. Imane El Khantouti, had a very invigorating discussion about how to get students and young professionals from emerging countries to persist in their goals of reshaping the space industry and promoting space applications in emerging countries, overcoming the challenges and difficulties, as well as aiming towards international cooperation in the field. He emphasized that it is important to direct our efforts to have diversity in the space sector and try to create partnerships. He concluded by saying that “failure is an absolute necessity”.

The following recommendations were provided by the seminar’s delegates:

1. Regional Collaboration on Space Applications working group: IAF to provide mechanisms that enable collaboration such as: build capacity of emerging countries to enable effective participation in collaborations; understand what the various players can contribute in a collaboration and what value each partner brings; appreciate the 3G’s: are there deliberate efforts put in place to and how is progress towards the 3G’s monitored? Observations in this conference – limited African participation and 3G’s not evident in the panels.
2. IoT and Space applications where the group: establishment of Pan African ecosystem where African countries can come up with shared Business model for financial and technical risk.
3. Legal and policy challenges of space applications working group: A policy should offer a roadmap. A country should identify its strengths and weaknesses and thus come up with potential space solutions, advising to find a way to impact citizens and economy positively, as space is a tool not an end goal.
4. Technology development for socioeconomic development: the working group advised to apply astronomy and space sciences to agriculture, landscaping, fire detection..., having multiyear budgets for space application and monopolizing resources.
5. Engagement of the Next Generation from the Emerging Countries working group: recommendations to stakeholders and governments:
 - i. There should be a change in the educational system policies and there should be long term investments in the area of space and its related technologies.
 - ii. invest in teachers by giving them the right training.
 - iii. make funding available and accessible for youth capacity building in technology.
 - iv. Emerging countries should invest in science camps and training centres, provide scholarships to talented and needy students.



International Space Forum at Ministerial Level

The Mediterranean Chapter 2019
5 September 2019 | Reggio Calabria, Italy



Fourth International Space Forum at Ministerial Level – The Mediterranean Chapter (ISF 2019)



The successful series of International Space Forums at Ministerial Level (ISF), returned to Italy for The Mediterranean Chapter, ISF 2019 that took place in Reggio Calabria on 5 September 2019.

Launched in 2015, under the auspices of the IAF Vice President for Science and Academic Relations, the International Space Forum represents an annual gathering at Ministerial Level aiming to encourage a global discussion and debate on the necessity of promoting a greater involvement of Universities and national Academies into space activities. Following the successful meetings held in Trento, Nairobi – the African Chapter, and Buenos Aires – the Latin American and Caribbean Chapter, this fourth edition of the Forum represented the logical continuation of the previous regional forums. The 2019 edition, held in Reggio Calabria, Italy, brought together major actors of the Mediterranean region to discuss the great opportunities space has to offer for the socio-economic advancement of the area.

The success of such a meeting begins with its preparation, but can be truly measured only by its participation and the engagement of the attending delegations. In this respect, this year was truly remarkable. A total of 14 countries from the Mediterranean region, and 20 space agencies and international organizations from all over the world, took part in the Forum. The involvement of various actors from government, space agencies, universities and technical institutions shows that these entities are well aware of the major role that space has to play in supporting the further development of the region.

As emerged during the Forum, by touching upon the three main topics - Maritime Surveillance, Space and Blue Economy and Space Education, Cooperation and Scientific Knowledge - the need to protect and preserve the Mediterranean region and its magnificent sea is a shared goal. Its unique geographical location and natural richness represents an exceptional resource that needs to be preserved. For this reason, the employment of space technologies and their application can be crucial in providing countries with the means to ensure said protection. Now

more than ever, the dialogue and scientific exchange between policymakers and key stakeholders is of vital importance in order to preserve this unique region of the world.

In order for space technologies to have a true worldwide impact, international partnership is key. For this reason, the IAF is particularly glad that so many different countries from the area gathered in Reggio Calabria, giving the opportunity to all to exchange ideas and points of view. Space Education and International Cooperation are a first, important step to develop and spread the technologies that could help the Mediterranean region to face major challenges. These and many more topics, were widely discussed during the Forum and were brought to light by the statements of the delegations. These statements, as well as the Reggio Calabria Page, will contribute to keep alive the spirit of the Forum, and will inspire new forms of cooperation and partnership, not only in the Mediterranean region, but throughout the whole world.

On 6 September 2019, in collaboration with the Italian Air Force, the ISF participants had the opportunity to visit the ASI Space Geodesy Center in Matera. The latter was established in 1983 and dedicated to the famous Italian scientist “Bepi” Colombo. It is one of the key nodes of the global geodetic network and also an earth-observation facility for acquiring, archiving and distributing data. In particular, the Centre contributed to the design, integration and testing of the civil ground-segment of the Italian radar satellite constellation COSMO-SkyMed, for which it has been providing operation and maintenance services since the launch of the first satellite in 2007. Since 2012, the Matera Space Centre has been one of the four stations of the ESA Core Ground Segment for the reception and real-time processing of radar and optical data acquired from the Sentinel satellites within the Copernicus programme.



International Astronautical Congress

21-25 October 2019 | Washington, D.C., United States





80 Countries

7 Plenaries

14 Press
Conferences

4 Highlight
Lectures

+6,600
Delegates

1 Billion
#IAC2019 users

52 IAF GNF
Sessions

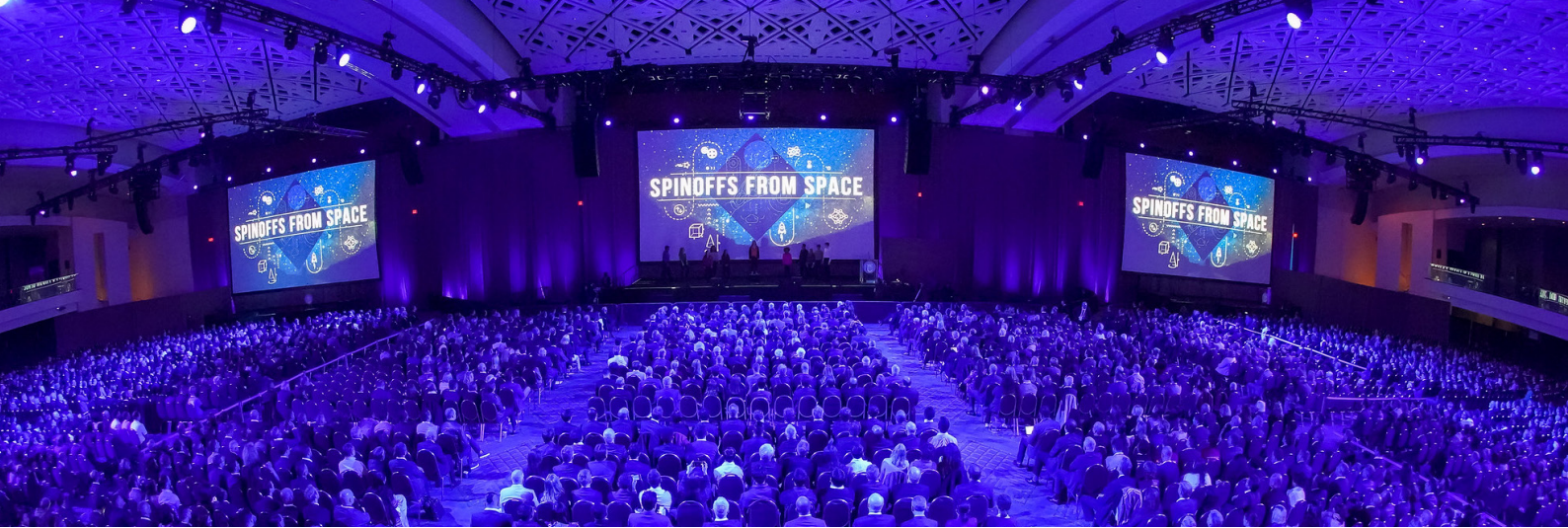
2 Late Breaking
News

181 Technical
Sessions

272 Exhibitors

+230 Interactive
Presentations

+1,800 Technical
Papers



IAC 2019 Plenaries



Heads of Space Agencies: Challenges and Opportunities in a Changing Space Environment

Monday 21 October 2019

The IAC 2019 kicked off the plenary programme in style with the leaders from five space agencies meeting for a discussion about the “*Challenges and Opportunities in a Changing Space Environment*.” In keeping with the theme of this year’s congress, each director discussed the past triumphs of their agency and how it paved the way for future space exploration programmes.

Jim Bridenstine, Administrator of the National Aeronautics and Space Administration (NASA); Sergey Krikalev, Executive Director for Piloted Spaceflight at the Roscosmos State Corporation for Space Activities (ROSCOSMOS); Sylvain Laporte, President of the Canadian Space Agency (CSA); S. Somanath, director of the Vikram Sarabhai Space Center at the Indian Space Research Organization (ISRO); Hiroshi Yamakawa, President of the Japan Aerospace Exploration Agency (JAXA); and Jan Woerner, Director General of the European Space Agency (ESA) each had plenty of news to share about the work underway at their respective space agencies. The session was moderated by Jean-Yves Le Gall, President at the International Astronautical Federation (IAF) and Pascale Ehrenfreund, Incoming President at the International Astronautical Federation (IAF).

Bridenstine began the session by discussing developments in NASA’s Artemis programme, which aims to establish a sustainable human presence on the moon as a stepping stone to the human exploration of Mars. Many of the agencies represented on stage are contributing to the Artemis programme and Bridenstine compared NASA’s moonshot to the International Space Station (ISS) in the sense that the agency is trying to “build an international architecture to achieve what none of us can by ourselves.”

Woerner focused on the ways that ESA is using its space assets to tackle some of the world’s most pressing problems like climate change and energy. He also noted the changing role of ESA as private companies play a larger role in space exploration. While Woerner acknowledged that there would always be a role for national space agencies, he said ESA is increasingly working to facilitate connections between private and public institutions in the aerospace sector.

Yamakawa discussed Japan’s past space exploration efforts, such as its groundbreaking exploration of Mercury and Venus. He gave a nod toward the push for the Red Planet, saying that “international momentum for lunar and Mars exploration is growing” and that the world is “ready to take the next giant leap.” His comments were followed by Laporte, who detailed the cutting-edge technology that the CSA is developing for deployment in low Earth orbit and beyond. A key aspect of Laporte’s vision is the Lunar



Exploration Accelerator Programme (LEAP), which is building the technologies that will enable future missions around Earth and on the lunar surface.

Krikalev discussed Russia’s new Cosmodrome, a launch pad that is currently under construction and will replace the current Cosmodrome in Kazakhstan as Russia’s main launch site. He also went into great detail about the manifold ways that space technologies improve life on Earth, through climate observation and telecommunications satellites that help first responders.

Somanath concluded the panel by highlighting India’s recent Chandrayaan-2 mission to the moon and discussing the country’s push to develop its private space industry. Somanath said ISRO is particularly focused on handing over the production of launch vehicles to the private sector as a way to lower the barrier to space access in India.

The challenges of space exploration remain daunting as ever, but as the heads of these space agencies showed, cooperation between nations and the public and private sectors in the final frontier is paving the way for an exciting new era of astronautics.

Evolving Apollo: The Next 50 Years in Human Spaceflight

Monday 21 October 2019

This year marks the 50th anniversary of humanity’s first “small step” into the cosmos, a milestone in space exploration that was duly celebrated around the world—including the International Astronautical Congress. During the secondary plenary session Frank Moring, former senior editor at Aviation Week and Space Technology, moderated a panel of distinguished guests from the aerospace industry who discussed how the Apollo missions shaped the last 50 years of spaceflight and what to expect in the future.

Lisa Callahan, Vice President and General Manager of Commercial Civil Space at Lockheed Martin, Jeffrey Manber, CEO of Nanoracks, George Nield, President of Commercial Space Technologies, Norah Patten, Scientist-Astronaut Candidate at the Irish Composites Centre, Ellen Stofan, John and Adrienne Mars Director at the Smithsonian National Air and Space Museum, and Jan Woerner, Director General of the European Space Agency each offered their perspective on the rapidly evolving future of human and commercial spaceflight.

Despite all the recent talk of creating a sustainable human presence beyond low Earth orbit, Woerner opened the session by voicing his opposition to the colonization of the Moon and Mars.

“Colonization means we are moving people away from Earth for the rest of their life,” Woerner said. “Neither the moon nor Mars are nice places to live. You live in a can and Big Brother’s watching.”

Woerner particularly addressed his criticism toward scientists who look to Mars as a backup of planet Earth, saying this is a “very bad excuse” for not taking care of our own planet. Nevertheless, Woerner saw a lot of value in sending people to other locations in the solar system, and Callahan laid out Lockheed Martin’s vision for establishing a base on the Moon or Mars.

As Manber pointed out, these sorts of ambitious human missions to other planets are enabled by a new crop of space



entrepreneurs that didn’t exist 20 years ago, much less 50 years ago when Buzz and Neil were headed to the moon.

“The market has developed enough that you can be an entrepreneur,” Manber said. “It’s remarkable, but a lot of people in our office at Nanoracks take that for granted.”

Everyone on the panel acknowledged that private industry was increasingly taking on roles in space exploration that were once the sole domain of governments, from building launch vehicles to space stations. But Nield underscored, this “doesn’t mean government doesn’t have a big role to play in the future.” In particular, he highlighted the role of government agencies in fostering the space industry by creating supportive legal frameworks, building partnerships between industry and academia, and developing critical technologies.

As a scientist astronaut candidate, Patten was one of the people on stage who stands to directly benefit as human spaceflight shifts from a government-only affair to one operated mostly by private companies. With the goal of becoming Ireland’s first astronaut, Patten has seen first-hand how greater access to space can directly benefit local communities around the world.

“Commercial companies are getting more involved in space and this has really opened up opportunities that weren’t there 5 or 10 years ago,” Patten said. “Our generation certainly wants to keep moving forward and keep pushing boundaries to benefit people here on Earth as much as possible.”

“Commercial companies are getting more involved in space and this has really opened up opportunities that weren’t there 5 or 10 years ago”

The Long-Term Sustainability of Outer Space: Advancing the Space Economy and Sustaining Space Industry Through Solutions to Space Security Issue

Tuesday 22 October 2019

Space is a big place, but it's starting to feel a little crowded. The days when only a handful of countries had access to the final frontier are long gone; today, dozens of nations and hundreds of companies are operating in low Earth orbit and beyond. Their satellites provide critical services to billions of people around the world and are expected to proliferate at unprecedented rates in the coming years as the first megaconstellations come online. But at the same time, regulations have struggled to keep up with the rapidly changing space industry and critical challenges to operating safely in space have begun to emerge.

The third plenary brought together a panel of experts who have dedicated their careers to ensuring that space remains secure and open for business. Fatih Ozmen, CEO of Sierra Nevada Corporation, moderated a wide ranging discussion between Jean-Loïc Galle, President and CEO of Thales Alenia Space, Daniel S. Goldberg, President and CEO of Telesat, Etienne Schneider, Luxembourg's Deputy Prime Minister and Minister of Economy and Space, Kay Sears, Vice President and General Manager of Lockheed Martin, and Scott Pace, Executive Director of the US National Space Council. Each panelist brought a unique perspective to the challenges and solutions of creating a sustainable space environment wrought from decades of experience.

Pace opened the conversation by challenging the widely held view that space is a global commons. While he acknowledged that these are "wonderful metaphors" he also pointed out that "from a legal standpoint they're really problematic." The problem, Pace said, is that when it comes to space, there is a fundamental lack of sovereignty. One solution might be to forge new treaties between space actors, but even this is hardly sufficient given how long treaties take to negotiate and the rapidly changing nature of the space environment.

"What the United States and other countries have done instead is work to develop best practices, norms of behavior, and voluntary guidelines that proceed from technical best practices, rather than trying to create overarching political solutions," Pace said. "We found that we can make more progress more rapidly by working at the national level for implementation."

Schneider described how the Luxembourg government opened up dialogues with new space companies to better understand their concerns and needs as the country moved to embrace the space economy. He said he found that one of their biggest concerns is establishing a clear legal



framework for space operations, such as ownership rights for resource extraction. By creating this sort of legal framework in Luxembourg, the country rapidly became a hub for emerging industries like asteroid mining.

"If everything in space belongs to humankind, that's not a good business model," Schneider said. "Nobody is investing in a company where you're not sure that you will be able to possess whatever you find in space. It was important to put in place a legal framework that allows these companies to do business."

One of the biggest topics of discussion during the panel was the risks and potential of telecommunication satellite megaconstellations. This will double the number of active satellites in orbit several times over in the next decade and as Goldberg pointed out, will be critical to bringing the other 3.8 billion people in the world without internet access online. But at the same time, Galle acknowledged, it also brings with it an increased risk for space debris that can jeopardize other satellites and space missions. He advocated for a greater effort on space situational awareness from major space actors to prevent disaster.

"We know that thousands and thousands of satellites will be launching in the near future and creating hundreds of thousands of pieces of debris in the next decade," Galle said. "If we don't react that will be a big mess."

Sears concluded the discussion by highlighting the changing role of space as a military domain and the need for government, military, and commercial actors to work together to ensure that outer space remains secure.

"When we used to have a benign space environment we could evolve our space capabilities more slowly or cautiously," Sears said. "This new security environment requires innovation. It requires flexible and rapid evolution of capability."

Inspiring by Leading:

Building and Sustaining the Global Space Workforce for the Future

Tuesday 22 October 2019

When the National Aeronautics and Space Administration (NASA) made its push to the Moon in the 1960s, the Apollo programme employed over 400,000 people from thousands of universities and private companies. It was a civil mobilization of human capital the likes of which had never been seen before—until now. The global space industry is growing at a breakneck pace, but finding and retaining young professionals who will carry the industry into the future is a task fraught with both challenge and opportunity.

During the fourth plenary at the 70th International Astronautical Congress, a group of space leaders from the government and private sectors came together to discuss how they are building a global space workforce. Clémentine Decoopman, Executive Director of the Space Generation Advisory Council (SGAC), moderated a lively discussion between Karen Andrews, of Australia’s Ministry for Industry, Science and Technology, Juan de Dalmau, President of the International Space University (ISU), Pamela Lincoln, Mobilization Assistant to the Chief of Staff in the US Air Force, and Bob Smith, CEO of Blue Origin about how their respective organizations are building the space workforce of the future.

Decoopman began the session by asking the panelists how they came to be involved in the space industry as a young professional. Their paths were varied—Andrews, for instance, was interested in working on high performance motor engines—but almost none of them aimed to get involved in the space industry from the start. Instead, their paths to space were forged by a combination of skill and personal interest.

“I think the Apollo mission had a profound effect on me and my father was an Air Force pilot,” Smith said. “So I’ve always had this need to be in this industry, but I don’t remember there was never a time in my life that I didn’t say, I want to be an aerospace engineer.”

Next the panelists discussed how they recruit and any recruiting challenges they have faced in their organizations. Smith said that Blue Origin looks at a diverse criteria in its candidates, but especially whether they have a passion for the mission that is needed to survive such a challenging work environment. Andrews noted that a major challenge is that there “are not sufficient numbers of students studying science and math at school,” and that the Australian space industry is working to inspire young people to pursue these career paths. Lincoln said the Air Force has a successful “Education with Industry” programme that allows talent sharing between the military and industry.



One of the major topics addressed during the panel was how to foster collaboration between the space sector and non-space sectors. As the panelists pointed out, the space industry has seen a lot of innovation over the past few decades by bringing in talent from outside the traditional aerospace sector. One of the best ways to foster this interdisciplinary collaboration, says De Dalmau, is by changing education. If you come from the finance world and are hired as the Chief Financial Officer of a new space company, it would be a huge benefit to have some basic knowledge of the technical side of space exploration.

“What we’re trying to do is design multidisciplinary space courses where all these non-space people can really get the basics of the other disciplines,” De Dalmau said. “We should design education programmes that making space understandable to someone who comes from a different speciality.”

As the panelists made clear, there are no shortage of challenges when it comes to attracting and retaining young professionals in the space industry. But neither have there ever been more opportunities for young people looking to make a difference in the world and help write the next chapter in the history of space exploration.

“We should design education programmes that making space understandable to someone who comes from a different speciality”

Heads of Emerging Agencies

Wednesday 23 October 2019

The fifth plenary highlighted the programmes from five emerging space agencies during a panel led by Pontsho Maruping, Chair of the Scientific and Technical Committee at the United Nations Office for Outer Space Affairs (UNOOSA). Their ambitious space exploration goals showed that when it comes to the final frontier, an agency's age is truly just a number.

Mohammed Nasser Al Ahbabi, Director General of the UAE Space Agency (UAESA), Valanathan Munsami, CEO of the South African National Space Agency (SANSA), Anond Snidvongs, Executive Director of Thailand's Geo-Informatics and Space Technology Development Agency (GISTDA), Carlos Augusto Teixeira de Moura, President of the Brazilian Space Agency (AEB), and Zolana Rui Joao, General Manager of Angola's National Space Programme Management Office (GGPEN) each detailed how their agency is using space exploration to further national goals ranging from improved telecommunications infrastructure to youth education.

Al Ahbabi opened the session, detailing the UAE's plans to send the country's first mission to Mars next year, its telecommunications ambitions, and its burgeoning astronaut programme, which sent its first astronaut to the International Space Station (ISS) in September. The UAE's space agency was only founded in 2014, but it has impressed the world with its rapid pace of development. But for all its scientific and economic goals, Al Ahbabi said one of the biggest impacts of the programme has been as a source of national inspiration. "We are trying to bring hope to the young people with space," he said.

Next, Munsami discussed South Africa's space programme, which he described as "just gearing up." He spoke of three main programmes undertaken by the agency, including Africa's only dedicated space weather system and its extensive ground station network. He also discussed how South Africa's assembly integration testing facility that is used to assemble satellites in the country. For the last decade, South Africa has used the facility to build cubesats for university programmes. But looking to the future, Munsami said the AIT facility will also be building 500-kilogram class satellites, particularly focused on those with optical and SAR capabilities.

Snidvongs discussed Thailand's evolving relationship with space exploration, which the country has been pursuing for over 30 years. Despite Thailand's "long heritage" with space exploration at the national level, Snidvongs said that the country is fostering a robust private space sector. In partnership with the government, these companies are helping Thailand expand its space assets in several key areas, including space weather and situational awareness, communications, and geoinformatics.



Teixeira de Moura highlighted the role that space exploration is helping bring Brazil closer together. "Brazil is a very huge country," he said. "The challenge we face in Brazil is how to integrate our people." One of the most promising solutions, in this respect, are telecommunications satellites. But Teixeira de Moura also highlighted the role that space is playing as an educational tool in the country. Eight federal universities in the country have aerospace engineering programmes, which allow students to launch atmospheric experiments on sounding rockets. "We have young people eager to apply their knowledge of engineering," said Teixeira de Moura.

Finally, Joao discussed the important role that Angola's fledgling space agency has played in getting the country back on its feet after a devastating 27-year war of independence. "As you can imagine, we had all the telecommunications infrastructure destroyed," he said. "We had to find a way to deploy communications fast to cater to education, telemedicine and so on." So in 2013, the Angolan government acquired its first telecommunications satellite, which made Angola one of just eight African nations in space. Looking to the future, Joao said Angola is working on its second telecommunications satellite and undertaking an extensive education programme so that its citizens understand how the country's space assets work.

The plenary demonstrated that it is an exciting time for the world's emerging space agencies, which are leveraging space assets to improve the welfare of their own citizens and foster international cooperation.

“We have young people eager to apply their knowledge of engineering”

Europa Clipper: Making a Mission to Understand Our Place in the Universe

Wednesday 23 October 2019

In 1989, the National Aeronautics and Space Administration (NASA) launched *Galileo* on a journey to Jupiter, where the spacecraft spent eight years studying the gas giant and its many moons. Of particular interest was Europa, a moon covered in a thick sheet of ice that scientists believe may conceal a planet-wide ocean of liquid water. Indeed, before *Galileo* succumbed to the strong radiation in the Jovian system, it discovered evidence that Europa may have many of the ingredients necessary for life. It's a tantalizing idea, but the only way to know for certain is to go back.

Now NASA is preparing for Europa Clipper, a dedicated mission to the Galilean moon to investigate its status as a possibly habitable world. Dipak Srinivasan, the Europa Clipper Telecommunications Manager at Johns Hopkins University Applied Physics Laboratory, moderated the IAC's sixth plenary panel in which Jennifer Dooley, the Europa Clipper Project Systems Engineer at NASA Jet Propulsion Laboratory, Karen Kirby, the Europa Clipper Deputy Project System Engineer at Johns Hopkins University Applied Physics Laboratory, Thomas J. Magner, manager at Johns Hopkins University Applied Physics Laboratory, Robert Pappalardo, a Europa Clipper Project Scientist at NASA Jet Propulsion Laboratory, and Bill Nye, CEO of The Planetary Society discussed the scientific goals and technical challenges of the Europa Clipper mission during the sixth IAC plenary.

The Europa Clipper mission will launch in 2025 and make dozens of close flybys around the icy moon, giving planetary scientists insight into its formation, chemistry, and suitability as a host for elementary life. The Europa Clipper mission isn't likely to find evidence of an intelligent civilization lurking beneath the moon's icy crust, Srinivasan explained. Instead, it is more likely to be similar to the types of extreme and simple lifeforms found near hydrothermal vents on the floor of Earth's oceans.



“There are two questions everyone asks: Where do we all come from and are we the only ones?”

“We suspect that Europa's ocean is ancient and that it's been simmering for 4 billion years,” Pappalardo said. “The level of current activity and past activity is something that's relevant to habitability through time.”

As Pappalardo acknowledged, finding *any* evidence of life of Europa, no matter how simple, would “change our world.” But to these sorts of observations require a spacecraft outfitted with a suite of extremely sensitive instruments. Kirby gave an overview of many of these instruments, which include an atmosphere-sniffing mass spectrometer, a dust analyzer to study Europa's plumes, a number of cameras to observe the moon at different wavelengths, and an ice-penetrating radar to probe deep into Europa's crust.

Although the spacecraft will be subject to extreme temperature swings from as low as -230 C up to 100C, Kirby said the Clipper team's “biggest challenge is surviving the radiation environment.” Indeed, it was the intense radiation around the Jovian moons that ultimately killed *Galileo's* electronics.

The Europa Clipper spacecraft is longer than a basketball court and weighs as much as an African elephant, Dooley said. When it is launched it will be the largest instrument in deep space and protecting all of its elements from the intense radiation would be nearly impossible. Instead, the bulk of the electronics are shielded in a radiation vault. This alone isn't enough to allow Clipper to survive a multi-year mission near Europa, however. To help limit the spacecraft's exposure to radiation it will make large loops around the moon so that it only spends brief portions of its mission in the most intense radiation.

The mission profile for Europa Clipper is daunting for its engineering challenges and remarkable for its ambition. Nye captured the sentiment of many in the room when he spoke of awe-inspiring nature of the mission, which may very well fundamentally change our understanding of the universe.

“There are two questions everyone asks: Where do we all come from and are we the only ones?” Nye said. “Missions like Europa Clipper is how we work toward answering them. If we were to find evidence of life on another world, everybody on Earth would feel differently about being a living thing in the universe.”

10th Anniversary Next Generation Plenary: Harnessing Citizen Science for the Future of Earth Observation

Thursday 24 October 2019

For the final plenary of the 70th International Astronautical Congress, a diverse panel of experts took to the stage to share how they see citizen scientists playing a role in understanding the data streaming back from Earth observation satellites. Masami Onoda, Director of the Washington, D.C. office for the Japan Aerospace Exploration Agency, and Kristin Wegner, Project Manager for GLOBE Implementation Office, moderated a lively discussion between Avid Gonzalez, Senior Member of the Institute of Electrical and Electronics Engineers, Caroline Juang, a PhD student from Columbia University, Fabiana Milza, COO and Co-Founder of IceKing GmbH, Jorge Nicolás-Alvarez, PhD student at CommSensLab at the Polytechnic University of Catalonia, and Ufuoma Ovienmhada, a graduate student in the Space Enabled Research Group at MIT Media Lab.

As Onoda noted in her opening remarks, “the widespread adoption of mobile devices and social media platforms coupled with the development of low cost sensors, has made it easier for the public to contribute to and engage in scientific research and monitoring.” Each of the panelists briefly described how they incorporated citizen science into their more traditional research.

Ovienmhada began the session by detailing a project to create a locally operated monitoring and forecasting tool that allows residents on Lake Nokoue in Benin to better understand changes in their local environment. The tool combines satellite data, drones and water quality data to provide actionable insights, and much of the data will be collected using a solar-powered microcontroller that transmits data over the cellular network.

Next, Nicolás-Alvarez detailed how he is experimenting with using common TV satellite dishes attached to people’s homes to precisely determine the orbit of telecommunication satellites using a technique called interferometry. This system, he said, could be used to get the very precise orbit determination needed for a geostationary synthetic Earth aperture satellite that could monitor the daily water cycle and help predict floods.

Milza explained how she developed IceKing, an app that will help scientists understand the world’s rapidly changing glaciers. Although Milza acknowledged that Earth observation satellites have proven invaluable for this task, she said they didn’t quite get the spatial resolution that scientists need. The best way to get these photos are to ask the thousands of tourists who visit glaciers each year take pictures while they’re on site with the app, which can help scientists understand both glacial dynamics and the impact of tourism on the glaciers.



Gonzalez detailed to the audience how he and his colleagues are leveraging citizen science to manage natural disasters. The idea is to have all the people affected by a natural disaster send pictures using their cell phones that can then be matched with the phone’s GPS information and compared with satellite imagery. This will better allow decision makers to respond to natural disasters and correlate satellite imagery with the realities experienced by the people on the ground in natural disaster areas.

Juang concluded the session by discussing Landslide Reporter, an app that allows citizens to take pictures and upload data after a landslide has occurred. Not only will this help keep people out of harm’s way, but by looking at the data in aggregate scientists can also get a better idea of risk areas for landslides that can augment pre-existing landslide databases like those maintained by NASA. So far, Juang said the programme has been very successful. After only a year of operation, it collected over 162 landslide points submitted by citizen scientists participating in the programme.

As low Earth orbit is filled with Earth observation satellites, scientists back on the ground are overwhelmed with a torrent of data used to monitor everything from the environmental conditions on a lake in West Africa to disaster areas in Peru. While advances in artificial intelligence are helping to extract important insights from this data, this panel made clear that there’s still a lot of room for citizen scientists to make important contributions to the understanding of our planet.



Highlight Lectures



MARSIS:

The Successful Search for Liquid Water on Mars

Tuesday 22 October 2019

In July 2018, a team of Italian scientists announced an amazing discovery. Using data from the European Space Agency's *Mars Express* orbiter the scientists detected a massive subglacial lake of liquid water on the Red Planet. The team, led by former ASI Chief Scientist Enrico Flamini, used over a decade of data from *Mars Express* to find the lake, which stretches for miles underneath the southern polar ice cap. It was the first time that a standing body of liquid water had been detected on Mars.

During the first highlight lecture at the 70th International Astronautical Congress Flamini detailed the process by which he and his colleagues discovered the lake and the implications of this discovery for the future of Martian exploration.

The real star of the show, said Flamini, was the Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS), a low-frequency radar on the *Mars Express* orbiter that allowed scientists to peer deep beneath the surface. The remarkable thing is that it's a century-old technology repurposed for the space age.

Scientists working in Antarctica in the 1930s first discovered that low-frequency radio waves could penetrate ice, but it wasn't until World War II that its applications became apparent. During the war, American planes kept crashing in Greenland because their radar altimeters gave incorrect information. Radars work by sending out a radio signal and then measuring how the signal is reflected back. In this case, the radar on the American planes was penetrating the ice all the way to the bedrock below—they simply couldn't "see" the ice.

It didn't take scientists long to realize that radar could be a valuable tool for studying what was beneath thick sheets of ice and years after the war radar was used to detect a massive lake under hundreds of meters of ice in Antarctica. Decades later, the basic same technique was used to detect liquid water below the Martian ice cap from a satellite.

"We started to think there was a similarity to what was occurring in Antarctica, where a huge number of lakes have been discovered, and the Martian surface at the polar caps," Flamini said.



The discovery of liquid water on Mars is exciting for a number of reasons, Flamini said. Perhaps the most obvious is its implications for the development of life on the Red Planet. Evidence suggests that Mars was once much warmer and home to vast lakes and rivers that carved valleys across the planet. As Flamini and his team discovered, the lake beneath the Martian ice cap appears to be in contact with the rocks and has a high salt content. If the conditions were right, this may have led to the rise of simple lifeforms.

"We may have observed with MARSIS some water that was there since when Mars was a wet planet," Flamini said. "If any kind of life had been present at the time, this could still be trapped in those conditions."

Another important implication of the discovery is for future human explorers. Water is a critical resource in space and the fact that it exists in liquid form in substantial quantities bodes well for the first astronauts to visit the Red Planet. Not only can this liquid and ice water be used for sustenance, but it can also be broken down into its constituent elements—hydrogen and oxygen—to make rocket fuel.

Until the first humans arrive on Mars, however, there is a lot of work to be done robotically exploring this underground reservoir and scouting for more evidence of liquid water on the Red Planet.

“We started to think there was a similarity to what was occurring in Antarctica, where a huge number of lakes have been discovered, and the Martian surface at the polar caps”

The Challenge of Exploring Our Sun: The 60-Year Odyssey to Parker Solar Probe

Wednesday 23 October 2019

In August, 2018, a spacecraft unlike any other was launched into space atop a ULA Delta-IV heavy rocket on a mission that will bring it closer to the sun than any human-made object in history. This is the Parker Solar Probe and although it's just begun its six year journey, it was a mission that was over six decades in the making.

This was the message delivered at the IAC's second Highlight Lecture by Nicola J. Fox, the director of the National Aeronautics and Space Administration (NASA)'s heliophysics division, during a conversation with Thomas Zurbuchen, Associate Administrator for NASA's science mission directorate.



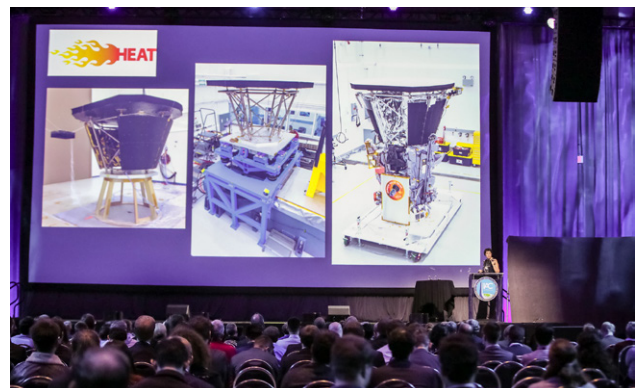
Fox began her lecture about “the coolest, hottest mission under the sun” by outlining the ways in which heliophysics helps us understand life on Earth. The continual expansion of the solar atmosphere gives rise to a protective bubble not only around Earth, but around the entire solar system. In addition to helping us understand

our own cosmic neighborhood, Fox acknowledged that studying our sun also helps scientists understand the evolution of other solar systems in the galaxy.

“Heliophysics is really the oldest of all scientific disciplines,” Fox said. “People often say ‘you’re the new kid on the block,’ but the very first people looked up and wondered about our star.”

The Parker Solar Probe has already sent images back from inside the sun’s atmosphere and on its closest pass it will come about seven times closer to the star than any spacecraft in history. But the probe is hardly the only tool in NASA’s heliophysics toolbox. Fox discussed the 19 operational heliophysics missions and six forthcoming missions that will shed new light on solar dynamics in the coming years.

Fox traced the origin of NASA’s robust heliophysics division to the work of Eugene Parker, who published a groundbreaking paper in 1958 that theorized that the solar atmosphere streamed away from the sun and shaped our heliosphere. But as Fox noted, not everyone wanted to hear what Parker had to say and he struggled to get his work published.



“One of the reviews actually said ‘If you’re going to publish in this area of science, you might want to go to the library first,’” Fox said.

Only a few years after Parker’s controversial paper was published, however, many of the predictions he put forth about the solar wind were proven correct. But as with any good science, the discoveries raised more questions than answers. Why is the sun’s corona so much hotter than its surface? What causes the sun to eject massive blobs of plasma? To solve these mysteries, scientists knew they’d have to go there.

Sending a mission to skim the surface of the sun sounds poetic, but as Fox noted it also involved incredible feats of engineering. One of the toughest aspects of the Parker Solar Probe mission was designing a heat shield that could withstand the blistering hot temperatures that would be experienced by the spacecraft—up to 1400 degrees Celsius.

So far, everything is working as planned on the Parker Solar Probe, a testament to the extreme engineering that made the mission possible. At present, the spacecraft has made three close passes to the sun as it works itself up to its maximum speed—430,000 miles per hour—for its closest pass in the coming years. But as Fox revealed, the data coming back from the spacecraft is already unlocking the mysteries raised by Parker more than 60 years ago.

“People often say ‘you’re the new kid on the block,’ but the very first people looked up and wondered about our star”

Monitoring Coastal Waters from Space - Highlighting the Chesapeake Bay Region:

Dramatic Advances Enable Better Understanding and Protection of these Vital Ecosystems, and their Immense Coastal Populations and Infrastructure

Wednesday 23 October 2019

The Chesapeake Bay region stretches along the coastlines of Virginia and Maryland in the eastern United States. It is the source of a vast fishing industry, which harvests blue crabs, clams, and oysters from its waters, and supports thousands of jobs. It is a leading tourist attraction in the area and a point of pride for locals. But the very same ecosystems that are a source of life for the plants, animals, and humans that call it home are also threatened by rampant pollution and a burgeoning coastal population. These problems are decades old, but the new generation of Earth-monitoring satellites are helping scientists understand and address challenges in the region like never before.

This was the topic of the third IAC Highlight Lecture, which began with opening remarks from Jean-Yves Le Gall, the President of the Centre National d'Études Spatiales (CNES) and an extended conversation between Laurence Monnoyer-Smith, Environmental and Climate Adviser to the President of CNES, and Neil Jacobs, Assistant Secretary of Commerce for Environmental Observation and Prediction at the US National Oceanic and Atmospheric Administration (NOAA).

“The first outer space missions gave us a new vision of our planet as a tiny speck in the middle of the universe,” Le Gall remarked. But since then, he observed, thousands of spacecraft have expanded this vision and given us a close-up



“The first outer space missions gave us a new vision of our planet as a tiny speck in the middle of the universe”

look at Earth. These satellites have helped with disaster management, shaped our understanding of climate change, and more recently have given us unprecedented access to the daily rhythms of human activity thanks to rapid revisit by constellations of Earth-observation satellites.

As a case in point, Jacobs opened his presentation with photographs taken from space that showed the Chesapeake Bay region in high resolution, including sediment deposits, barrier islands, and even human-made constructions like bridges. The pictures were stunning, but the real value of space-based monitoring, Jacobs said, is the ability to see how the region changes over time.

A lot of the marine life in the Chesapeake Bay region is incredibly sensitive to changes in water quality, water temperature, and other environmental factors like seasonal algae blooms. Getting a big picture understanding of how these environmental factors are changing is difficult from the ground or even from a plane, but by leveraging space-based images, scientists can get a better understanding of how the regional ecosystem is changing in near-real time.

This big picture view enabled by Earth-observation satellites is incredibly important for a number of different reasons. Not only does it help scientists understand changing ocean currents and the dynamics of local ecosystems, but it also helps laymen, whether it's fishermen looking for a big catch or vacationers looking to avoid a cold front in the ocean currents.

As the world grapples with a changing climate, the ability to monitor local and global ecosystems from space will only continue to increase in importance. Like space, the ocean is a “final frontier” of human knowledge and exploration. But as research by NOAA and other organizations goes to show, bringing these two domains together opens up new possibilities.

IAF World Space Award Highlight Lecture

Thursday 24 October 2019

This Highlight Lecture reflected the awarding of the International Astronautical Federation “World Space Award” to the Apollo 11 crew. The award itself was presented at the IAC opening ceremony and the recipients were Neil Armstrong, Michael Collins and Buzz Aldrin. The Highlight lecture was moderated by John Logsdon, Apollo Historian and Professor Emeritus at George Washington University. He discussed the importance of Apollo 11 and its legacy together with Buzz

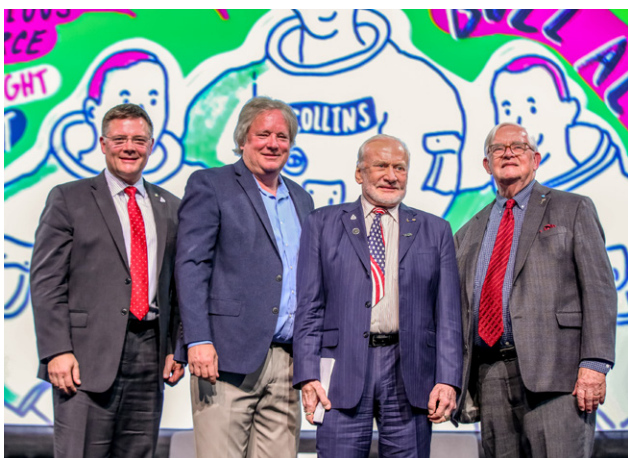
Aldrin, Apollo 11 Moonwalker, Rick Armstrong, son of Neil Armstrong, and Doug Wheelock who is a current NASA astronaut.

“For making an Unparalleled Impact on Space Exploration and on Human Civilization and for Earning their place in the Pantheon of Human Achievement through their Heroic Feats during the Apollo 11 Mission in 1969 and their Subsequent Careers”



“For making an Unparalleled Impact on Space Exploration and on Human Civilization and for Earning their place in the Pantheon of Human Achievement through their Heroic Feats during the Apollo 11 Mission in 1969 and their Subsequent Careers”

Highlight Lecture 4





Late Breaking News



OSIRIS-REx Dancing with Asteroid Bennu

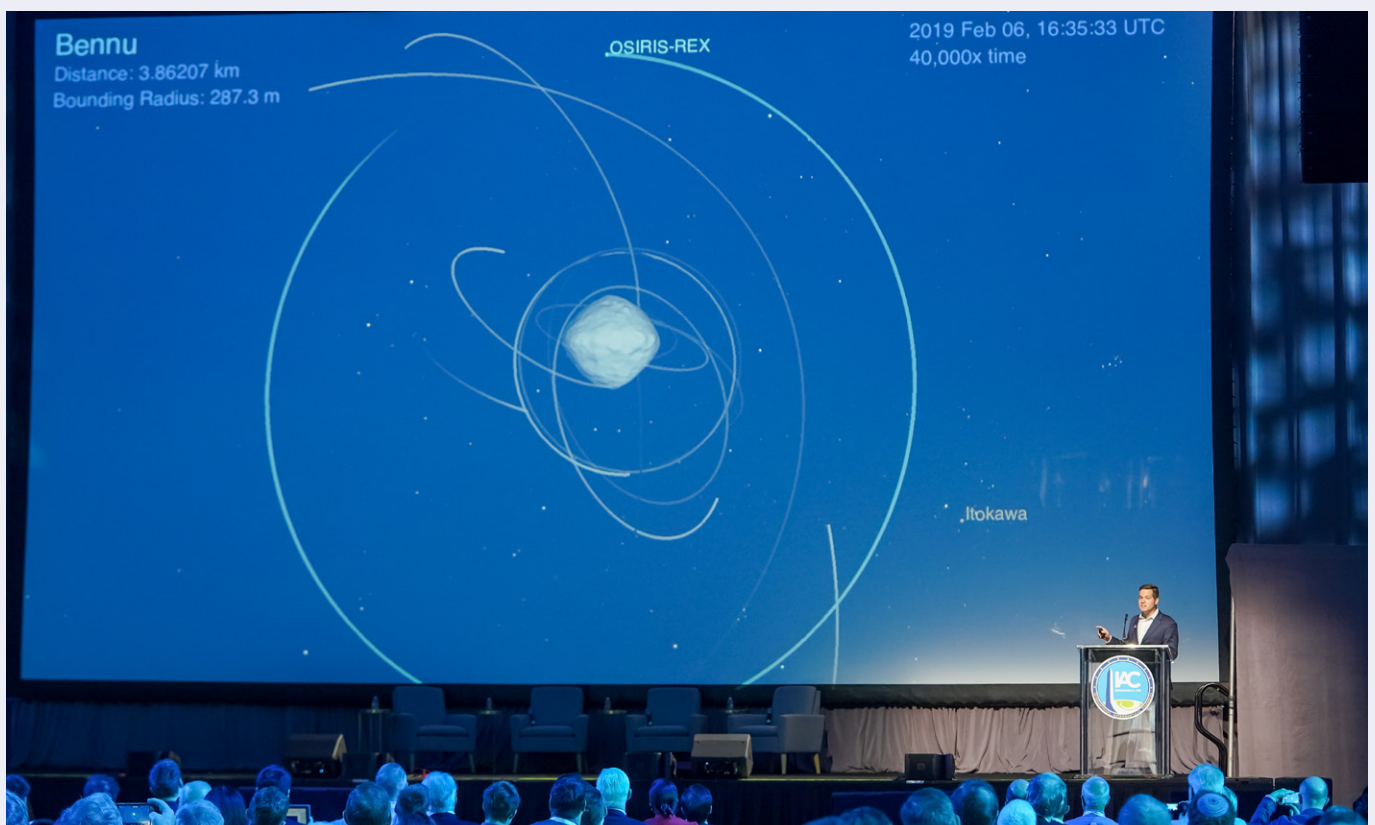
Friday 25 October 2019

On New Years Eve, 2018, a spacecraft called OSIRIS-REx entered into an orbit around asteroid Bennu after a two year journey from Earth. Since then, the spacecraft has been scouring the asteroid for an ideal sampling location. Once a final site is selected by the OSIRIS-REx team at the National Aeronautics and Space Agency (NASA), the spacecraft will briefly lower its orbit to collect a sample from the asteroid before beginning its long journey back to Earth.

During the first Late Breaking News session at this year's IAC, Kenneth Getzandanner, the OSIRIS-REx flight dynamics manager at NASA's Goddard Flight Center, announced that the team is getting close to selecting its primary and backup sample sites. Getzandanner and his colleagues selected four final sample sites last July, and since then OSIRIS-REx has been doing detailed studies of each site.

After showing the audience several stunning photos recently taken by OSIRIS-REx, Getzandanner said that the team was on the cusp of completing its first recon mission, a high-pass flyover of each of the final four landing sites. Once the final data is returned from this recon mission in early November, the team will be able to select a prime and backup sample selection site. After that, it will do two more recon missions in a "medium" and "low" orbit to get a detailed topographic map of the final two sites.

After the recon missions are complete, Getzandanner said the OSIRIS-REx team will perform two rehearsal sample retrievals. If everything goes well, the stage will be set for OSIRIS-REx to retrieve a sample from Bennu. It will collect about 60 grams of surface material during a five second contact before departing from the asteroid and beginning its journey back to Earth. If the retrieval goes as planned, it will mark the largest asteroid sample ever brought back to Earth and will provide a wealth of knowledge about the nature of the minor planets in our solar system.



Introduction to the United Arab Emirates Astronauts Programme

Friday 25 October 2019

Just a month before the IAC, Hazzaa al-Mansoori became the United Arab Emirates (UAE) first astronaut to travel to the International Space Station. This was a big step for the UAE's budding space agency, which was created just five years ago. But as detailed during a Late Breaking News session, it is just the first step for the country's ambitious human spaceflight programme.

Salem Al Marri, the Assistant Director General for Science and Technology and Astronaut Programme Manager at the Mohammed Bin Rashid Space Centre (MBRSC), Adnan Al Rais, Senior Director of Remote Sensing and UAE Operations Support Center Manager at MBRSC, Saud Karmastaji, Director of Corporate Communication at MBRSC, and Mariam Al Zarooni took to the stage to discuss al-Mansoori's historic mission and the next steps for the Emirati astronauts programme.

"Throughout our programme, we intend to inspire regional and Arab countries to participate with us," Al Marri said. "It's time to make sure that the missions are scientifically significant and that the programme will be sustainable."

Al-Mansoori conducted 16 experiments during his time at the ISS, six of which occurred in space while the others looked at changes that occurred before and after spaceflight. Importantly, Al Zarooni pointed out, the experiments were chosen based on their educational potential as part of the agency's "Science in Space" programme. These experiments will be used as teaching material in the country to inspire its next generation of space explorers.

"The last astronaut that was sent from our region was 32 years ago," Al Marri said. "Our region is very large and

“Throughout our programme, we intend to inspire regional and Arab countries to participate with us”

encompasses a very young population. Most of the people in the region weren't alive the last time an astronaut was launched, so it was time to change that."

After discussing the astronaut selection process, the leaders from the UAE space agency focused on the role that space exploration plays in fostering national pride and curiosity in the country's youth.

"Everyone was glued to the TV and tweeting, sending pictures and participating with us at the space center," Al Zarooni said of al-Mansoori's mission. "We've had a really, really good impact on the general public."

Looking to the future, the UAE space programme is going to expand its astronaut corps and focus on building a sustainable space exploration programme as its main strategic objectives. The agency will also be focused on a number of scientific missions, including its Emirates Mars Mission scheduled to launch next year. As each facet of the UAE's space programme was discussed, the panelists highlighted the role these programmes will play in education, providing solutions to pressing national issues like resource security, and fostering international cooperation.





IAF Global Networking Forum (IAF GNF)



Monday

21 October 2019

The 2019 IAF Global Networking Forum was opened by the IAF President Jean-Yves Le Gall announcing a programme of more than 50 IAF GNF sessions that discuss the most recent and stimulating topics in research and developments from numerous stakeholders and experts in space. Gabriella Arrigo (Vice President, Science & Academic Relations and Global Networking Forum) welcomed the audience reiterating the importance of the inclusiveness of the 3Gs - Gender Generation and Geography.

Six speakers participated in the first IAF GNF session entitled EO as a Pillar of the Space Economy and Perspectives of Industrial Policy. EO was introduced as a new cultural revolution introducing innovative downstream applications. It is contributing to a new economy powered by smart growth and introducing dramatic social change. For Europe, the operationalisation of Copernicus and the tremendous quantity and quality of EO data it is delivering has introduced profound changes for small and medium-sized businesses.

Omar Valdes (Market Development Officer for European GNSS Agency (GSA) that operates Galileo and EGNOS explained that the Agency is designed to meet the needs of the end-users. The Agency has successfully employed a methodology that incorporates three strands of market knowledge, understands how to address the evolving user requirements and a system of appropriation to acquire the funding to ensure GSA meets user requirements.



Agnieszka Lukaszczyk from the American EO company Planet explained that Planet now collaborates with ESA and Copernicus because apart from commercial interests, the role of EO data from both the private and public sector is essential to address climate change, perhaps the most pressing concern of our time. The New Space sector is leading the way and new global markets will open to address the world's problems.

During the short session on European Space Strategy: Achievements and Perspective, Elżbieta Bieńkowska (Commissioner, Internal Market, Industry) reminded the audience that since 1975 ESA has been a major player in the space sector. Currently, ESA has an annual cumulative budget of 7 billion Euros and intends to preserve its



position as the world's second-largest space power. She indicated that 6% to 9% of the economy in the 28 European Member States relies on space. The underlying strategy for Europe is the culture of cooperation which not only benefits Europeans but beyond.

A summit on Mankind's Return to the Moon in the NewSpace Age was hosted by Namira Salim founder of Space Trust. She opened the session with her song about the Moon. Ryan Whitely explained that the National Space Council is responsible for delivery on the Space Policy Directive 1 announced by President Trump in 2017. The directive provides for a U.S.-led, integrated programme with private sector partners for a human return to the Moon, followed by missions to Mars and beyond.

Kevin O'Connell from the Office of Space Commerce estimated the global space economy to be worth about 400 billion dollars today, rising to around 4 trillion dollars in the

next 20 years. International and commercial partnerships are essential to fulfil the objectives in Space Policy Directive 1.

Margaret Kiefer elaborated on NASA's long tradition of collaboration. She indicated that currently, NASA has around 700 agreements with national, international and commercial partners. Typically 70% to 75% of NASA's budget goes to private entities.

She expressed her view that the international community needs no additional encouragement and already has the enthusiasm for lunar exploration missions.



Tuesday 22 October 2019

The Industry Story Telling Session: Virgin Galactic was introduced by Eric Stallmer (President, Commercial Spaceflight Federation). The first of the six speakers, George Whitesides (CEO at Virgin Galactic), exhibited the new spacesuit on stage during the session. He explained that Virgin Galactic had made substantial progress and the first human spaceflight would be made soon. Donato Amoroso (Deputy CEO, Thales Alenia Space) spoke about the Thales Alenia Space's rich history and exploring the Moon and Mars as the natural evolution from the capabilities it had developed in LEO. Andrew Rush (CEO and president of Made in Space), explained that spacecraft size is limited by the launch vehicle. In-space manufacture of large antenna or solar panels will remove this limitation. Industrialising space through on-orbit manufacturing is the only way to accommodate a future where millions of people will live and work in space.

Stéphane Israël (CEO, Arianespace) summarised Ariane's record of placing 611 satellites in space since 1980. He confirmed that the James Webb telescope will be launched in 2021 using Ariane 5. ESA has many plans to go the Moon using Ariane 6, which has the capacity to deliver 8 tons to lunar orbit. Ariane 6 will start lunar missions from 2023.

Brent Sherwood (VP, Advanced Development Programmes for Blue Origin) confirmed Blue Origin's participation with NASA's Artemis lunar Moon. He went on to assert the importance of lunar exploration which could allow fundamental understanding of the ancient Earth and the origins of the Solar systems.



Gwynne Shotwell (SpaceX, President) explained that SpaceX operates on a tight timeline and takes risks. Starship development has been accelerated and the failures along the way are opportunities to learn. Current aspiration includes getting Starship to orbit in 2020 and to the Moon by 2022. But the most significant mission is Dragon-2, a human crew to the ISS in 2020.

In a session entitled A Grand Tour of Global Space Policy Issues, Brian Weeden (Technical Advisor for Secure World Foundation) moderated a focused discussion on how governments establish policy and develop regulation for private individuals and industry. Bill Beckman (Director of NASA's programmes at Boeing) summarised the existing issues of space debris that preoccupy satellite operators. Currently, there are 40,000 items in space that are tracked. Today, typically 3 satellites undertake a collision avoidance



manoeuvre every day. Once mega constellations are in orbit, it is projected that typically a collision-avoidance manoeuvre will need to take place once every 8 minutes.

Marco Fuchs (CEO of OHB Systems AG) stated that global space policy has a limited effect on national security. The military is a significant customer for the private space sector. Policies should be developed that will allow both industry and military to fulfil their respective objectives. Cybersecurity is an increasing concern and not just for the military. Kai-Uwe Schrogl (Chief Strategy Officer at ESA) assessed the issue of space resource utilisation as a huge thing and a potential game-changer in the future. He reminded the audience that resources in outer space were a global common and thus not available for national appropriation, as defined by the 1967 Outer Space Treaty. Marco Fuchs added that there should be no reason why the mechanisms establishing and enforcing rules that have been working so well in other sectors cannot work for space.

Jim Chilton (Senior Vice President of the Space and Launch division of the Boeing Company) moderated a session on Commercial Crew Starliner. Mark Mulqueen (Boeing's Programme Manager for the International Space Station) summarised ISS achievements since its launch in 1998. It has covered a distance of 1.2 billion miles in Earth orbit, hosted 3000 experiments and continues to make contributions to science and nurture international collaboration.

Chris Ferguson (Boeing Director of Crew and Mission Operations at Boeing and commander of the final Space Shuttle mission in 2011) outlined the upcoming events for Starliner. A pad abort test is scheduled for November and



the first uncrewed operational flight of Starliner to the ISS on 17 December 2019. Subject to the success of both, the first Starliner crewed flight is expected to be scheduled for the first half of 2020. The designated crew for that flight will be Ferguson himself, Mike Fincke, a NASA astronaut with experience of three Space Shuttle flights and on her first spaceflight, US naval test pilot Nicole Mann.

Boeing's future plans for Starliner beyond ISS include applications such as leasing to other countries, commercial operators for space tourism, academia, businesses and manufacturing. Buzz Aldrin asked a question at the end session: "Can we return from lunar orbit using Starliner as designed today". Jim Chilton replied that the existing design of the heat shield will not support a return from lunar orbit but it could be adapted.

Moderated by Aoife Van Linden Tol (Director & Artist, IAF Committee for the Cultural Utilisation of Space (ITACCUS)), the Alive in Space panel discussed what it is that makes us feel alive. A common answer included the importance of the creative aspects of our work. Michael Garrett (Director, Jodrell Bank Centre for Astrophysics, UK) expressed the importance for him of discovery, working with young people and his family. There is widespread support in bringing art and artists into space. The culture in space will not simply be a copy of that what exists on the Earth but a new space culture will gradually evolve.

Joe Landon (VP Advanced Programmes Development for Commercial Civil Space, Lockheed Martin) moderated a TedX style presentations from 4 entrepreneurs in the private sector on Industry Deep Dives: Incorporating the Moon into Earth's Economy. Peter Beck from Rocket labs outlined the dramatic benefits of shrinking electronics and the ability to integrate onto a single processor of a few grams the multiple functions that in the past required many kilograms of hardware. Rocket labs started off providing launch services to LEO but have now announced launch services to the Moon. Rocket Labs has built two factories with a capacity of building a rocket every 30 days.

Nobu Okada founder of Astroscale is one of the emerging private sector companies that have taken on the challenge of removing orbital debris through End of Life (EOL) provision and Active Debris Removal (ADR) services. He highlighted that it is not just the technology but also a business case and international regulations that will determine the pace of implementation. Astroscale will be demonstrating its

capability to remove debris through an End-of-Life Services by Astroscale-demonstration (ELSA-d) mission in 2020.

Chester Gillmore (VP Spacecraft Development & Manufacturing at Planet Labs) explained that their existing constellation consisted of 5 Rapid Eye, 120+Dove and 14 SkySat satellites conducting EO from LEO. Most of Planet Labs employees focus on analysing the large quantities of data replenished daily, using custom-built change detection and image classification algorithms to provide actionable customer insights.

Valanathan Munsami moderated the session Outcomes of the Global Conference on Space for Emerging Countries – GLEC 2019. Two of the panelists had attended the 3-day event held in April 2019 in Marrakech, Morocco. The key issues that came out of the conference were that senior politicians in emerging countries do not understand the benefits of space, funding models for space are unclear, space expertise and skills are lacking, regulation and legislation are absent and finally, the basic infrastructure for space does not yet exist.

The IAF Startup Pitch Session consisted of 8 diverse pitches of 5-minute duration each. The pitches included the smallest and most efficient propulsion units, a 1cm high precision satellite navigation system, online platform for tools, products and services for space customers and companies, embedded space systems, prebiotic foods for long-duration space missions, tools that use AI to analyse

climate data to predict and avoid disease outbreaks, computer games based application for delivery of STEM education and In-orbit space debris monitor. Morpheus-Space was declared the winner with their small and efficient propulsion units.

Simonetta Di Pippo (UNOOSA Director) moderated the session Leaving No-One Behind: Opportunities to Support Inclusiveness Through Space-Based Applications and Space Exploration. The session summarised the results of the IAF supported 27th Workshop on Space Technology for Socio-Economic Benefits held a few days prior to the IAC 2019. The IAF has adopted a Global Innovation Agenda that has fostered the principles of 3Gs - Gender, Generation and Geography, as well as an International Platform for Diversity, Equality and Astronautics (IDEA). One of the popular topics that came out of the workshop was the theme of exploration. To that end, the IAF has organized the Global Space Exploration Conference in St. Petersburg, Russia between 9 and 11th June 2020.

A panel on Singapore – Regional Vision to Co-Create, Build Capacity, and Expand Space Applications for New Users, consisted of 4 representatives from Singapore and was moderated by Lynette Tan from the Singapore Space and Technology Association. The discussion focused on the developments of the space sector in Singapore, which currently has 10 satellites in orbit, 8 of which were built at the Satellite Research Centre in 8 years and all have been successful.

Wednesday 23 October 2019

The first session on day three on The Evolving Role of the Public Procurement Authorities becoming an anchor was moderated by Peter van Beekhuizen (Director at Bexperience). The session was opened by Jan Woerner (ESA Director General), whom expressed his longer view beyond NewSpace into a future he called Space 4.0, reflecting the 21st-century setup that includes many new space-faring nations, new technologies and a large innovative industry sector. The role of space agencies has also evolved e.g. ESA is now a partner, broker, mediator, facilitator and an enabler.

Robbie Schingler (Planet's Co-Founder and Chief Strategy Officer) stated the US government signed a multi-year contract with Planet Labs the week before to provide EO data to the National Reconnaissance Office and NASA. However, it is not the US government but the agriculture community that is its largest customer.

Philippe Pham (Director of Operations of Airbus Defence and Space) described the successful public-private relationship



between Airbus, ESA and the EU behind the European Data Relay System (EDRS) satellites. ESA has been key in establishing EU as an anchor customer by providing high-speed laser communication. Airbus has now developed an operational capability of 60% higher data rates than initially expected. It is now working on the second generation of laser comm satellites, ground terminals and will be used by aircraft and High Altitude Pseudo Satellites.

Bill McNally (CEO at Acquisitionpro) recalled that during the 1970s government customers were primarily NASA and the Department of Defence. At the time he worked at NASA, the main requirement was to turn ballistic missiles into space launch vehicles. He highlighted the importance of the financial viability of new companies. Sometimes, new companies can bring innovative new technical solutions but are not financially sound.

Eric Morel de Westgaver (ESA Director of Industry, Procurement and Legal Services) emphasized the role of ESA as an enabler. He reminded the audience that ESA is a research and development organization. ESA fulfils the role of an enabler more than as an anchor client. In the case of EDRS, ESA was the enabler that mediated Boeing to deliver the needs of the EU.

The following IAF GNF session consisted of a keynote, a panel discussion and a TedX style talk. Étienne Schneider (Deputy Prime Minister and Minister of Economy, The Luxembourg Government) outlined the strategy and series of steps that have allowed Luxemburg to diversify its economy into developing a space sector. The panelist advised the young entrepreneurs to build powerful visions for their company. In the long term, it helps to attract partners, investors and employees. Diversity in the team is also key. A company founder should ensure that the people who work in the company do not look like her or him.

Oniosun Temidayo Isaiah (Managing Director, Space in Africa) summarised the progress of space activities by African countries. He highlighted the interesting observation that many outside as well as inside Africa are unaware of the progress being made in space by African countries. Nine African countries have 35 satellites in space. Over the next 5 years, more than 50 satellites are expected to be launched by 16 African countries. By 2024 the African space industry will be worth over 10 billion USD.

Will Crowe (CEO High Earth Orbit Robotics, Australia) initially pursued the idea of building “Google Maps” of space resources, where the resources are asteroids that pass-through space between the Earth and the Moon. Last year it was 80 asteroids and 56 so far this year. But he timeline of 15 years for recovering such resources was too

long. However, a project to generate HD images of orbiting satellites for the Australian defence department has been agreed and will start in 2019.

Joost van Oarschat (founder and CEO Maana Electric, Netherlands) has the vision to build large scale solar power parks in deserts around the world to meet the growing electricity needs. Once completed on Earth Manna Electric, want to provide a similar provision first on the Moon and eventually on Mars.

During the session on Forming, Storming, and Norming the Future Lunar Exploration Enterprise, Clive Neal (Professor, University of Notre Dame) identified a key differentiator relative to the Apollo era: Going back to the Moon will mean securing a return on investment. That return will come from the lunar resources. The first step is to quantify those resources through in-situ prospecting.

Marshall Smith (Director of Human Lunar Exploration Programme, NASA) emphasized that return to the Moon ought to be sustainable. Open architecture and interoperability standards will be essential for international and commercial partners.

Bernardo Patti (ISS and Exploration Programme Manager, ESA) announced that the ESA exploration programme will be presented at the next ministerial council. The programme will consist of cornerstone activities of humans in LEO, Lunar Gateway, Lunar Surface and the surface of the Earth. Libby Jackson (Human Exploration Programme Manager, UK Space Agency) asserted that a sound business case for future investment in space is essential for the UK. The return on investment is not just the scientific objectives but the resulting inspirational element, especially for the younger generation, is of key importance.

Megan Kane (Co-Founder, Disrupting Space) Lisa Johnson (System Engineer, Loft Orbital), Agnieszka Lukaszczyk (Senior Director, European Affairs), Ann-Sofie Schreurs (Senior Scientist and Possum Alumni, Planet) and Nancy Wolfson (President, Disrupting Space) were the four panelists on “Lessons from Business Women in the Space Industry – Positive Tales from a Journey Through a Male-Dominated Industry”. The panel opened with the observation that the





audience consisted mostly of women. Other comments included the unrepresentative coverage of women by the media diminishing the visibility of role models for young girls. Women tend to be timid and humble when they should be assertive and proactive. Women should continue to seek out new challenges in career and personal life. It has recognised that the space industry, which is continually changing, will benefit from a greater female presence.

Johannes von Thadden (Senior Vice President and Head of Business Growth Space Systems, Airbus Defence) moderated an international panel “To the ISS, the Moon, Mars – and then some: A 360° Discussion on Humanity’s Exploration of Our Solar System and Beyond” the opening comments reminded the audience that exploration of the solar system especially Moon, Mars and Venus helps us to understand our past on Earth and thus our future too. The greatest contribution of the ISS was bringing together the numerous international partners in space.

To sustain human presence on the Moon requires making use of resources on the moon rather than taking everything from Earth. The initial goal is to establish a regular affordable transport service to the Moon. Astrobotics plans to take 7 NASA and 7 other payloads from international partners to the Moon on its Peregrine lander by 2021. NASA YP Town Hall was an opportunity for Young Professionals to interact with NASA Administrator Jim Bridenstine. Following an overview of how NASA will operate in the future, which unlike in the past will involve long term sustainable programmes that will include LEO, Lunar and Martian exploration. Unlike in the past, NASA will engage commercial and international partners. In response to one question, the administrator highlighted some benefits for people on Earth from the various space programmes. He listed the internet from space, navigation services and the increase yields attained by the agricultural sector whilst reducing the use of water for irrigation by 25%.

In the session Industrializing the Solar System – Launching the OffWorld Industrial Robotics Workforce Programme, Jim Keravala (CEO, OffWorld, Inc) examined the scenario of humans living off-world. He argued that the starting point is to reinvent industry on Earth. In the long term what is required is a solar system toolkit that can enable us to do any task, any conditions in any location in the solar

system. Millions of robots categorized by task and capability will operate autonomously in swarms.

Alexander MacDonald (Senior Economic Advisor, NASA) opened the session on ECOSYSTEM for Sustainable Space Exploration – Involving New Space, Non-Space Players. He concluded that the time frame by when In Space Resource Utilisation will make sense is not yet clear. NASA’s approach is to validate the models for water on the Moon including the data from its 2022 Viper mission to the lunar south pole.

In 2015 the UN adopted 17 Space Development Goals to be attained by 2030. Jan Woerner (ESA DG) identified three specific examples where space is helping to achieve the UN’s SDG during the session on Space Supporting the UN Sustainable Development Goals 2030 Agenda. SDG 13 requires urgent action against climate change. Space-based Earth Observation satellites are probably the most potent element helping to address the challenges to Earth’s environment. Astronauts from many nations work onboard the ISS, which helps reduce political tensions between nations on Earth. Astronauts also support education through their roles as speakers at international fora and local communities.

The session on On-Orbit Servicing - OOS and Related Technologies Enabling Next-Gen Space Missions and Ultimate Exploration dealt with emerging and exciting themes. Consortium for Execution of Rendezvous and Servicing Operations (CONFERS) is an industry-driven organization that has developed guidelines for in-orbit operations and Rendezvous and Proximity Operations (RPO). Jim Armor (CONFERS CEC) summarised how CONFERS guidelines centred on 4 principles of Consensual Operations, Compliance with Relevant Laws and Regulations, Responsible Operations and Transparent Operations. CONFERS has produced a draft international standard which is intended to be formally adopted as an international standard ISO 23440.

Northrop Grumman has launched its first Mission Extension Vehicle (MEV-1). The MEV is designed to grapple an existing satellite that has almost depleted its fuel and thus approaching the end of life. Rather than replacing the satellite, the satellite operator can commission an MEV and extend the life of an existing satellite by 5 to 10 years.

The MEV-1 launched on 9 October 2019 will demonstrate its operational capacity with an already defunct Intelsat 901 satellite in a GEO graveyard orbit. Since this is a demonstration flight it will be conducted in the GEO graveyard orbit as a precaution. MEV-1 uses electric propulsion and can be used for station keeping, orbital inclination change and orbit relocation. The Space robotics Strategic Resource Cluster is a European consortium including EU, ESA, Industry and academia that is developing solutions for OOS solutions.

The session on We Are Going, and The Technologies to Get Us There, was organized by the AIAA. Jennifer Edmunson (Geologist, In-Space Manufacturing Engineer, Jacobs Corporation) commented that the Moon is a great resource for rare elements as well as water for fuel and a key ingredient for developing human habitats on the lunar surface. The success of private sector companies in in-space



manufacturing, additive manufacturing, robotics and autonomy will help determine the pace at which human activity will be established on the Moon. In addition, NASA's CLPS and Viper programme will make a significant contribution to the lunar missions in the next decade.

Thursday 24 October 2019

The first session of day 4 of IAC 2019 The Future Lunar Ecosystem and its Business Potential, addressed the renewed interest in the Moon which started at the beginning of the year with China's Chang'e 4 mission. Since then Israel and India have also attempted a soft lunar landing. From 2020, there will be many journeys from the Earth to the Moon especially through NASA's CLPS, Viper and Artemis programmes. From 2021 the private sector will ramp up lunar missions including Blue Origin, Rocket Labs, SpaceX with Starship, Astrobotics and ispace.

The nascent lunar ecosystem will include representatives from traditionally non-space industries. Companies such as NGK, Bridgestone tyres and Toyota with pressurised lunar rover from the motoring industry and Japanese airlines.

Astrobotics has declared it will deliver a payload to the lunar surface for a fixed rate of 1.2 million USD per kg. Intuitive machines and ispace also plan lunar landing in 2021.

Trent Martin (Vice President of Intuitive Machines) represents 1 of 9 companies that are participating in NASA's CLPS programme. Along with ispace and Astrobotic, Intuitive Machines is planning to land a spacecraft on the Moon by 2021. Data is the key. The new ecosystem planned will offer a high data rate transmission from the Moon, including 4k video.

In line with this year's IAC theme - Power of the Past, Promise of the Future, the session was held on the topic "Space Museums and Science Centres: Heritage and Education in





a Fast-Changing World”. Three speakers spoke about the value of museums and science centres in the USA, China and France. China’s Space Exhibition Hall with 200 square meters of floor space was established in 2005 and houses spacecraft from navigation, space science, earth observation, communication, lunar and human space programmes. A new space exhibition hall was opened in April 2018 with 500 square meters. China sees them as platforms for international exchange and collaboration.

In the session “Space Traffic Management is Needed Now! IAA, IISL, and IAF Join Their Forces to Propose Long Term Sustainability of Space Operations,” representatives from the three organizations IAA, IISIL and IAF provided an overview of the progress of their work since they agreed to work together during IAC 2018.

Corinne Jorgenson stated that the definition of STM first established in 2006 remains unchanged. The STM roadmap study covered spacecraft during the three stages of launch, in orbit and re-entry, as well as in-space resources. Additional private and public resources including radar, telescopes and laser ranging are required to detect, map and identify objects in space. A formal white paper is expected to be published leading up to IAC 2020.

The engagement with space by African countries was highlighted in a session entitled Towards a Formal African Space Programme. Africa has taken significant steps in space since 2012, when the 55 countries in the African Union agreed to develop an ingenious space programme. Between 1998-2019 35 satellites have been launched belonging to Angola, Nigeria, Egypt, Algeria, Kenya, Morocco, Ghana and South Africa. An African space policy, strategy and an Africa Space Agency have been established based in Egypt. The 4 main application areas that are the initial focus include EO, Communication, Navigation and Science. Tangible improvement in the lives of ordinary Africans should be the primary objective of the African Space Agency.

During the session, The Mars/Moon Generation Lawyers: A Discussion of the Legal Framework Taking NASA Back to the Future, a panel consisting entirely of NASA lawyers explained how NASA manages the contractual, intellectual property, commercial and international arrangements for NASA’s Artemis mission to the Moon and then to Mars. NASA’s procurement has moved away from NASA directing

the design and approach to allow the private contractors to take the lead on how best to meet NASA’s requirements.

NASA has established a contract with the private sector for launch services, ISS resupply and crew transport service and this is the model that will be used for establishing and supplying the Gateway and missions to the lunar surface. NASA’s international agreements comply with international law and the Outer Space Treaty but there are challenges. The Moon agreement has not been signed by the majority of the nations and many of the technical capabilities available in the 21st century were not envisioned in 1967.

Robert Zubrin (founder of the Mars Society) opened the session on Martian and Lunar Analogues and spoke about the Mars Society that he founded in 1998. A Mars analogue was established on Devon Island in the Arctic to explore the technologies that will be most useful on Mars. A similar analogue has also been established in the desert in Utah. The goal is to write a book of tactics that will be of use to the first people to arrive on Mars. It was not an isolation study but an opportunity to explore Mars on Earth.

George Danos (Chair of the Analogue Project, Moon Village Association) shared the 9 principles of the Moon Village Association. An international Moon Village analogues working group to foster international collaboration is key, to that end, the Moon Analogue Consortium was announced during this session.

The initial comments for the session, Spaceports: Gateway to a Global Space Economy, emphasized that spaceports do not only attract launch service but many more including centrifuge, avionics, zero-G flights, astronaut training, spacecraft testing and more. Bright Space Technologies published a report estimating that currently, the global space economy amounts to 360 billion USD, of which less than a quarter is from governments. Financial institutions UBS and Morgan Stanley estimated that this will grow to 1 trillion USD by 2020. Carley Scott (CEO, Equatorial Launch) reported on the progress of Australia’s spaceport in the Northern Territories, Roberto Vittori (ESA Astronaut & Space Attaché at Italian Embassy in Washington, D.C.) explained the distinction between spaceports and launch sites. Only a departure from a launch site will necessarily take you into space.



Japan plans to expand the current 12 billion USD to 24 Billion by the early 2030s. UAE is establishing a spaceport to co-locate at the Al Ain Airport in Dubai. Virgin Galactic and Nanoracks are developing plans for participation.

Dan Hicks (CEO, Spaceport America) shared 5 points to support a successful spaceport - key partnerships should come before investing in and building infrastructure, establishing a life cycle logistical support, building a future workforce including engaging with the local schools, communities and understanding the benefits of collaborating with spaceports around the world.

The 4th International Space Forum at Ministerial Level – The Mediterranean Chapter, was held on 5th September 2019 in Italy. Two of the outcomes were the engagement of the academic community (University of Reggio Calabria) for the first time and identification of specific benefits for the Mediterranean countries that could potentially be exploited elsewhere too.

Stamatios M. Krimigis (Counselor on Space, Minister of Digital Governance of Greece) commented that Greece fully shares the objectives of the ISF. Maritime surveillance and navigation are especially important for Greece. Commercial shipping and tourism represent two of the largest contributors to the national economy, so space-based services are essential.

In his presentation on Global Navigation Satellite System (GNSS) Market: What's Next for Industries, Applications and the User Community, Omar Valdés (Market Development Officer, European GNSS Agency) summarised the findings of the 6th edition of the GNSS Market Report published in October 2019. It incorporates data from road, maritime, rail, aviation and space applications. The report identified that the existing 1.6 billion low-cost GNS enabled devices are expected to grow to 2 billion by 2029. The 6 billion consumer devices with a GNSS receiver is expected to grow to 9 billion in the next decade. The rate of growth in consumer devices has seen a slowdown compared to the previous decade. This is considered to be the result of consumers' holding on to their devices for longer, motivated by environmental concerns.

GNSS is increasingly deployed with Satellite-Based Augmented Systems providing an advanced safety system in the civil aviation and maritime domains. Drones and search

and rescue are also seeing growth. The global GNSS economy is valued at 2.5 billion Euros. The USA has 28%, Europe 27 %, Japan 20% and China 10%. Space applications include formation flying (for mega constellations), attitude determination and new applications from the NewSpace sector. The data collection for the report this demanding and that is why the report is published every other year rather than annually.

The theme of space debris was addressed again by another session - Space Sustainability Rating: Addressing the Orbital Challenge. In May 2019, The World Economic Forum and working with MIT and the University of Texas announced the Space Sustainability Rating, a set of voluntary rules and processes for the space industry to mitigate the impact of space debris. Simonetta Di Pippo (Director of UNCOBUS) confirmed that the UN General Assembly will be endorsing this work and establish a working group and a technical committee for ongoing support.

SSR is a voluntary scheme and the ratings have yet to be defined. It is in the interest of all space stakeholders to understand that a safe and sustainable orbital environment is a fundamental pre-requisite for their business model. One of the panelist commented on the almost absence of representatives from China and Russia at the congress. For SSR to work it will require participation from all space actors around the globe.

Governance of Space Activities – Comparative Studies on National Space Policy and Law. One of the panelist explained that governance is not the same as government. Governance is the exercise of authority and control. Space is an international domain. The Outer Space Treaty prohibits countries from assuming sovereignty of any part of outer space (article 2), countries are responsible for supervising and controlling their private sector actors in space (article 6) and holding individual countries are held liable for any damage arising from actions of their private sector actors.

Only 25 countries have implemented a national space law and 5 countries (including India, Japan and Brazil) are in the process of implementation. There are 4 approaches with which national space laws can be applied. 1: National territorial jurisdiction where the state has complete authority, 2: Sea launch or air-launch where jurisdiction lies with the country operating the service rather than the location from where it is conducted, 3: personal jurisdiction where it is the laws of the home country of the person or company

that apply and 4: jurisdictions is selected by choosing to formally register in a specific country.

A common theme was that the more recent a country has established its national space law the more comprehensive it is, i.e. they tend to incorporate all 4 methods. Of the 10 countries in the ASEAN region, 4 have a space policy 4 do not and 2 are in transition.

The session, Artemis: Enabling Lunar Exploration, was organized by Lockheed Martin. LM has been exploring the solar system with NASA for decades and currently supporting NASA with 5 active space missions at Benu, Jupiter and 3 at Mar. LM will be playing a significant part in NASA's CLPS, Gateway and a crewed lunar lander. LM's Mars Basecamp mission will incorporate a Martian orbiter and a surface lander.

Friday 25 October 2019

Public
day

In the session entitled From the Moon to Mars NASA's Artemis Programme, NASA Administrator Jim Bridenstine spoke about broadly about NASA's ambitions and achievements and took audience questions during the Public Day that was open to the general public.

In March 2019, US President Trump announced the Artemis programme and directed NASA to get the next man and the first woman onto the lunar surface by 2024. Since the announcement, the NASA administrator has been engaging the private sector and international partners to participate in the Gateway and Artemis programme. During the week of the IAC 2019, Italy and Japan publicly announced their intention to participate with NASA.

Following the remarkable success of New Horizons and the science it returned, Bridenstine announced that he considers Pluto to be a planet once more. During this session, the administrator awarded John Culberson (former United States Representative) the NASA Distinguished Public Service medal for helping secure funding for NASA's missions.

During the IAF - ASE Astronauts Event, five astronauts (Sergey Krikalev, Mary Cleave, Charlie Bolden, André Kuipers and Reinhold Ewald) recalled their experiences of spaceflight and took audience questions. All astronauts have been to the ISS and commented on the profound

importance of international cooperation. André Kuipers went as far as recommending that the ISS should be awarded the Nobel Peace Prize.

Charles Bolden reflected on seeing the continent of Africa from space and knowing that as an African American his ancestor came from there, was emotionally moved to tears. During the session, Sergey Krikelev presented Charles Bolden the Order of Friendship on behalf of President Putin.

The final IAF GNF session for IAC 2019 was a session on The Science-Fiction Continuum. Art Dula who worked with author Robert Heinlein was asked by Heinlein's widow to establish Heinlein Prize Trust for which he is a Trustee. Dula commented that Heinlein's greatest achievement was social rather than technical. Writing in 1950s America, Heinlein had women as starship pilots and strong African American protagonists in his novels.

J.J. Abrams Hollywood film director contributed to the session by video. He commented on the common experience that many professional scientists today were motivated into that profession by reading science fiction including Star Trek. An audience member commented that science fiction writers such as Ray Bradbury were invited to places like Caltech to help inspire scientists and engineers.





IAC Special Sessions



Monday 21 October 2019

The first of the two Special Sessions on the opening day of IAC 2019, *Get Ready to Protect Earth from Asteroids – Planetary Defense in Your Hands*, was concerned with protecting Earth from asteroid collision, arguably the highest potential impact to all life on Earth from space. Organizers Alex Karl, a member of the IAF Technical Committee on Near-Earth Objects and Nancy C. Wolfson, President of Disrupting Space, framed the panel discussion around a scenario of an asteroid on a collision course with Earth and the questions that would arise – what would be your thoughts? Is there anything we can do about it? Where will it hit? What are the consequences?

Lindley Johnson, Planetary Defense Office at National Aeronautics and Space Administration (NASA), explained that an asteroid collision is an extremely rare event but it has happened before in Earth's history. The impact of a collision would be local but the relative speed of around 17 km/s would release a huge amount of debris that could have global long-lasting consequences.

A distinguished panel including Bill Nye, CEO of The Planetary Society, asserted that the Earth will get hit but we just don't know when. Only around 90% of the asteroids that could hit the Earth are known so more observational facilities are required on the surface of the Earth and in space. Infrared detectors can operate in space but not from the surface of the Earth.

Early detection by several years before the predicted collision is essential to consider and implement potential remedial action. The second panel brainstormed ideas for human spaceflight in the coming decade when platforms in Earth orbit (ISS), Lunar orbit (the Gateway) and the lunar surface will become operational simultaneously.

The second SpS session, *ISS-Moon-Mars: Using Spaceflight Platforms to Study and Simulate Future Missions*, was one of the largest panels with over a dozen speakers with three organizers, Julie Robinson, Chief Scientist, International Space Station Division, Oleg Kotov, Cosmonaut and Deputy Director for Science, Institute of Biomedical Problems and Livio Narici, Professor of Applied Physics, Università di Roma, Italian Space Agency. Jens Jordan Director, Institute of Aerospace Medicine at DLR, explained that missions to conduct life sciences in space can improve life spans on Earth and space. As a permanent platform, the ISS allows us to understand the hazards of spaceflight in LEO. Jenifer Fogerty highlighted the lessons learned from the ISS with almost two decades of experience in space showed that the human body is remarkably adaptable, resilient and robust.



Loss of muscle and bone mass in the human body has been a major concern for prolonged exposure to micro-gravity. Masaki Shirakawa, head of JEM Utilisation group, shared results of their experiment in which they simulated a 1G environment for mice using a centrifuge onboard the ISS. The rodent centrifuge provides a capability to compare the effectiveness of artificial gravity under spaceflight conditions.

Humans on long-duration missions to Mars will require protection from radiation that is more intense than that found in LEO. Maria Antonietta Perino, Director of Relations with Space Associations, Thales Alenia Space, spoke about radiation protection for a space habitat with walls filled by water. A common observation shared by many of the speakers was the need for sharing resources and research facilities. Instead of bearing the burden of initial and operational costs, collaboration at all levels will reduce costs and facilitated the sharing of ideas resulting in innovative solutions to many difficult problems.

“Humans on long-duration missions to Mars will require protection from radiation that is more intense than that found in LEO”

Tuesday 22 October 2019

During the four sessions on the second day of the IAC 2019, the SpS programme covered a diverse range of topics including Earth Observation, a unique outreach programme championed by a European astronaut, the resonance between the work of exobiologists and scientists searching for extraterrestrial intelligence and the value of analysing EO data using AI.

The first session, *Home Planet 2030 – The Role of Earth Observations in Studying Our Planet*, was opened by the organizers, James Graf from NASA and NOAA's Harry Cikanek. The focus of the panel was to highlight the need for different national agencies to work together to address the difficult challenges of acquiring accurate measurements from the increasing assets in space to help support operational services such as severe weather prediction and emergency response. Josef Aschbacher, Director of Earth Observation Programmes at ESA, outlined the unique meteorological data collected by Copernicus and the first UV Lidar in space onboard the recently launched Aeolus satellite that can measure vertical wind profile, understand climate science and prepare for new operational capabilities. The potential of New Space companies offers exciting new opportunities but also uncertainties. New Space companies announce services with huge potential but a year later some cease to exist or morph into something large and substantial.

Sandra Cauffman, acting Director of Earth Science at NASA, emphasized NASA's rich legacy in Earth Observation since 1958. NASA's Earth Science data archive is expected to increase to 250 petabytes by 2025. Data in this distributed archive is acquired from a fleet of traditional satellites but also small satellites, cube sats, hosted payloads, instruments onboard the ISS and purchased through commercial providers. EO data is essential to successfully respond to threats from natural and human-induced environmental change. A report compiled from this data was published in 2018 "Thriving on Our Changing Planet A Decadal Strategy for Earth Observation from Space (2018)".

Stephen Volz, Assistant Administrator for Satellite and Information Services, National Oceanic and Atmospheric Administration, commented that data purchased from commercial providers add value and they are encouraged to make products and offer services which do not yet exist. NASA and NOAA do not simply buy existing data but define what is needed. The discussions on data rights, new services and price points are ongoing. NOAA has productive engagement through regular user group workshops in many communities and some e.g. fire management communities, are not aware that data exists. Increasing this engagement will offer new opportunities through which EO data can be exploited by individuals, communities and organizations.



The second session, *Global Launch SpaceBuzz: Launching Millions of Children into Space*, saw the global launch of a non-profit foundation called SpaceBuzz. An innovative outreach and educational project introduced by Dutch astronaut André Kuipers who spent 204 days in space during two separate missions on the ISS. With a centrepiece of a space-vehicle styled bus, the SpaceBuzz, children can get the experience of spaceflight using virtual reality and 4D technology. The SpaceBuzz visits schools to engage children in simulated spaceflight training including preflight briefing, post spaceflight briefing and participate in a press conference. SpaceBuzz is free and operates an open access model with local adaptability regarding astronauts, countries and continents.

The penultimate session of the second day, *EO+AI - The Game Changer in the Way We See the World*, focused on the rapid development in sensor and digital technologies to acquire, access, distribute and analyze EO data. The session was organized by Agnieszka Lukaszczyk, Senior Director of European Affairs at Planet.

With increasing quantity and fidelity of data collected from space, e.g. Planet can image the globe daily at a three to five meter per pixel resolution, it may be possible to predict the outbreak of diseases e.g. malaria before it happens. Philippe Pham, Senior Vice President, asserted that combined with data on temperature, climate, history of previous outbreaks, precision epidemiology the power of artificial intelligence can now offer a realistic possibility to predict future outbreaks. Quality of the predictions depends heavily on the quality and quantity of data and the AI learning algorithms. He also raised the ethical concerns of collecting data, for example via Sentinel from the region of the world without the consent of the affected communities. Currently, this relies on the business case, policies and values of the companies and national agencies that collect and analyze the data.

Rebecca Moore, Director at Google Earth, commented that Google had developed a set of AI principles and best practices that preserve privacy, safety, accountability and scientific excellence. Participating in military projects that make use of AI has been explicitly excluded. She also emphasized the importance of high standard unbiased training data. For AI to deliver accurate and meaningful outcomes data used for AI training should include a range of attributes including race, sex, cultural and national identities.

The final SpS session on the second day, *Artificial Intelligence in Space: Are Intelligent Space Objects the Promise of the Future?*, was facilitated by Lucien Rapp, Law Professor & Director, SIRIUS Chair, University Toulouse. The six speakers represented diverse views on AI onboard space objects from the national space agency, legal, academic and commercial perspectives.

Thomas Fouquet, Advisor to the Director, Innovation Applications & Science, CNES, asserted that AI systems and applications are now a mature billion dollar market and growing. AI has a critical role in upcoming missions



the Moon where in-situ manufacturing of oxygen, water, fuel and food will soon be developed. Mega-constellations such as Starlink depend on AI to implement automated collision avoidance and end of life system in their satellites. Missions to Mars by virtue of the distance and remoteness will rely on AI for mission support including logistics, energy and communication.

Brent Sherwood, Vice President of Advanced Development Programmes, Blue Origin, provided an overview of the 21st-century manufacturing approach. He highlighted the importance of developing visualisation tools for all the analysts and engineers who build the final product. Automated systems will monitor and interface with the human-machine interface to address the individual needs of future astronauts. This will include fare-paying space tourists who will have a significantly different set of needs.

“AI has a critical role in upcoming missions the Moon where in-situ manufacturing of oxygen, water, fuel and food will soon be developed”

Brian Israel, Co-Founder & Legal Counsel at ConsenSys Space, introduced trusat.org an open-source satellite tracking tool based on the Ethereum blockchain that incorporates satellite autonomy. Amongst other attributes, the tool could be used to protect the capability to de-orbit even if communication with Earth is lost or the company goes out of business. At a high level, he proposed the idea of a blockchain-based smart contract where participating satellite operators could receive a credit for manoeuvring their satellite to prevent a collision. A centralised escrow-type account would hold funds from all satellite operators and ensure that operators would be fairly treated and the cost of an operator going bankrupt was accounted for at the outset.

The Q&A covered issues of AI ethics, drift in neural networks, encouraging transparency and confidence-building measures in how autonomous systems are designed and built. Transparency will be essential in preventing the issues of malware and privacy we have in modern large scale social media applications from appearing in future neural networks.

Wednesday

23 October 2019

The first of the four special sessions on day three entitled *Space Traffic Management: Working Together to Enhance Safety and Sustainability* was organized by George Nield, President, Commercial Space Technologies. A panel of five expert speakers spoke about the current status of technology, legal and regulatory framework associated with Space Traffic Management.

Former NASA astronaut Sandy Magnus, Executive Director Emeritus at American Institute of Aeronautics and Astronautics published a position paper in 2017 *Space Traffic Management (STM): Balancing Safety, Innovation, and Growth* which discussed collision avoidance and data sharing, debris mitigation, behavior guidance and a comprehensive communication strategy. This work is still in progress with the participation of the commerce department and commercial operators. The results of this work are available publicly on the AIAA website. The group is continuing with its work and seeking an increase of membership with a data-driven focus on products and encouraging the engagement of policymakers.

Diane Howard, Executive Secretary, International Institute of Space Law, provided an update on the work conducted by IISL. One of the main tasks was to establish through a white paper, a common lexicon at a high level for those who have an interest in STM, stakeholders and policymakers.

Moriba Jah, Space Scientist and Astrodynamist at the University of Texas, summarised the growing number of actors, including in the private sector, involved in independently acquiring SSA data. A commercial radar operator Leo Labs opened a new radar station in New Zealand, Planet has a large constellation of satellites in LEO and Slingshot aerospace specialising in AI are able to contribute to SSA data. Majority of spacecraft operators use the free source of SSA data from the US Space Command. He concluded that the location of space objects is not known with sufficient precision necessary to determine key events such as Time of Closest Approach. Also, no agreed rules exist to determine which operators have the obligation to perform a collision avoidance maneuver in the case of two objects from different operators approach each other. Daniel Oltrogge, Director, Center for Space Standards and Innovation, Analytical Graphics, concluded that typically ten conjunctions take place each week. The inaccuracies of the existing SSA data result in false alarms and this is likely to worsen as New Space makes its entrance in the coming years raising the global number of spacecraft to 57,145.

A panel entitled *Futures Past and Present: Space Architecture in Imagination and Reality* commemorated another 50th anniversary in 2019, the film *2001 a Space Odyssey*. Panellist and astronaut Sandy Magnus pointed out that despite the two decades of operation, the ISS still has 2-D

Earth-based architectural design. For example, all the lights are on the ceiling. In reality, astronauts live and work in a 3-D environment.

Bob Smith, CEO at Blue Origin, commented that the ideal extraterrestrial place for humans is not another planet or a spacecraft but a manufactured world. Brand Griffin, Space Architect of Genesis Engineering Solutions, revealed that Von Braun's space station design was inspired by submarine compartments. Blue Origin and other players should develop facilities for architects and engineers to train and work in neutral buoyancy environment just as astronauts train in water.

During the session, *Young Minds Meet Space Leaders: Words Into Action*, the winners of the Space4Youth competition were revealed. The competition was organized by the United Nations Office for Outer Space (UNOOSA).

Affairs in collaboration with Space Generation Advisory Council. UNOOSA Director, Simonetta Di Pippo, announced the three winners of the 27th Workshop on Space Technology for Socio-Economic Benefits. They were Milica Milosev from Serbia, George Profitiotis from Greece and Arthur Nielsen Demain from the Philippines. Each winner was assigned a moderator to help progress their space-related project.

The final session for the day, *The Future of Space Operations Across Industries*, attempted to identify synergies between the operational concepts amongst the growing space industries in the 21st century. These industries include mega-constellations, on-orbiting servicing, in-situ manufacturing (in space, on the Moon or the surface of an asteroid) or the developments coming from the New Space companies emerging around the globe.

Guillaume Tanier, General Manager & Lead Designer at Telespazio VEGA, identified the New Space characteristics of cheaper, quicker and agile solutions which could have a wider application. Gary Calnan, Co-Founder and CEO, CisLunar Industries in Luxembourg, expressed the need and value of developing systems to salvage and recycle space debris and resources in space. He repeated a common observation in the space industry that the current UN agreed voluntary period of 25 years to remove non-operating space object is too long.

Kyle Acierno, Vice President of Global Sales and Strategy at ispace observed that China's lunar landing on the far side of the Moon (January 2019) triggered a global resurgence of interest in lunar missions. This was a motivation for NASA's announcement to hasten its return to the Moon as well as missions by Japan and private companies. Whilst private sector interest in the Moon continues to grow public sector missions remain highly nationalistic.

Thursday 24 October 2019

In the first session on day four, *The Immortal Spaceship: A Discussion on the Use Cases and Value of Persistent Platforms*, Deborah Tomek, Deputy Director of NASA Langley Research Center, explained that spacecraft look the way they do (their size, mass and physical structure) because of the constraints of the launch vehicle. On-orbit Servicing, Assembly, and Manufacturing (OSAM) would remove those restrictions.

Ben Reed, from NASA's Goddard Space Flight Centre identified the critical role of Power and Propulsion Element for NASA's Gateway. Currently targeted to launch in 2022, the PPE will make use of Solar Electric Propulsion and will allow access to any point on the lunar surface and act as a space tug for visiting spacecraft. It will need to be in place at the Gateway before the first human crew arrives. Persistent platforms will have to operate in isolation in remote locations for extended periods in the absence of a human crew. Thus they will rely heavily on robotics, additive manufacturing, modular structures, high level of autonomy and Artificial Intelligence for health monitoring and predictive maintenance. Partnerships with international space agencies and commercial operators will help with costs, logistics and management.

The second session on *Planetary Protection for the Future: Science, Exploration, and Commerce*, was concerned with how the space community could organize itself to support the existing policies on planetary protection. Simonetta Di Pippo, Director of United Nations Office for Outer Space Affairs, reminded the audience that article Six of the Outer Space Treaty requires that states bear international responsibility for their national space activities whether carried out by governmental or non-governmental entities.

NASA's James Green indicated that NASA has always taken planetary protection seriously. A planetary protection panel reviews all planetary mission including the planned Dragonfly mission to Saturn's moon, Titan. Constant vigilance is an essential part of planetary science forward contamination (from Earth to the solar system) concern as well as the risk of contaminating the Earth with extra-terrestrial sample return missions. The COSPAR panel has been recently reconstituted. It has no commercial representation at the present but representatives from the private sector will be invited to attend future conferences.

The third SpS session focused on *Using Open Space Data in Developing Countries*. Jeanne Holm, distinguished





Instructor from the University of California, Los Angeles, identified SERVIR (https://www.nasa.gov/mission_pages/servir/index.html) as a global network of regional partners dedicated to environmental management. It was established as a joint venture by NASA and the US Agency for International Development in 2004 by researchers at NASA's Marshall Spaceflight centre. It hosts satellite data and geospatial information as well as predictive models and science applications.

Data and tools on Servir have been used by over 30 countries including projects to reduce risk to food, water and mitigate the impact of natural disasters. Other projects provide early warning alerts to fires in Nepal and algae in San Salvador.

Katherine Townsend, CEO, Open Data Collaboratives, shared some of the projects including a hackathon involving 4000 young people across middle east Africa, a project to clean up several cities including Kampala and Accra. Volunteers identified unauthorised local waste dumps on satellite maps. By locating authorised waste dumps on the same maps, they helped reduce the waste dumped in public places. Temidayo Oniosun, Managing Director of Space in Africa, summarized some of the challenges in using space data to help manage wildlife poaching, satellite based pest monitoring for farmers, monitoring cocoa farms and snow-fall in South Africa.

The session *Space Applications of Machine Learning and Artificial Intelligence* was organized by Ali Nasser, Programme Manager and Consultant at LDC and Ksenia Lisitsyna, Business Development Manager, Precious Payload. AI and ML are two of the most important technologies that will determine how spacecraft will behave and operate in the coming decades. Ewan Reid, CEO, Mission Control Space Systems, described his experience of operating a drone in a simulated Mars environment in the Arctic to support the first helicopter for the Mars 2020 mission. His experience highlighted the difficulty of verification and validation of applications for deep space missions. The algorithms for hazard avoidance, terrain classification and deep learning require large data set which is not generally available. The technologies of Artificial Intelligence and Machine Learning for deep space science missions are in the early stages.

Martin Ristov, Junior Member of Technical Staff, MDA Corporation, explained that the Gateway, in a peculiar Near-Rectilinear Halo Orbit has a six to eight day lunar orbit, will typically allow eight hours of communication with the Earth per week. Unlike the ISS, the Gateway will not be permanently occupied and will have to operate autonomously without direct human intervention for extended periods. Autonomous systems will also be needed to support medical diagnoses during deep space missions for example to Mars. The algorithms currently in development for self-driving cars may offer a starting point for use in space.

“Data and tools on Servir have been used by over 30 countries including projects to reduce risk to food, water and mitigate the impact of natural disasters. Other projects provide early warning alerts to fires in Nepal and algae in San Salvador.”

Friday 25 October 2019

On the final day of IAC 2019, the four SpS session focused on gravity measurements in space, launching spacecraft without a launch tower, in-space manufacturing and exploring interstellar space. In the first session, *Atomic Test Masses and Atom Interferometry for Inertial Sensing and Gravity Measurements in Space*, Professor Holger Mueller from the University of California, Berkeley, outlined the unique insights that gravity measurements in space can offer science. Ultra-high precision measurements can help verify and refine the accuracy of fundamental constructs such as the gravitational constant, gravitational waves, dark matter and the standard model itself.

Sheng-Wey Chiow, Research Technologist from NASA Jet Propulsion Laboratory explained that experiments conducted onboard the Gravity Recovery and Climate Change Experiment Follow-on (GRACE - FO) can help scientists better understand the interior of planets, including the Earth, orbit determination of spacecraft via radio-tracking, for example with the Bepi Colombo mission on its complex trajectory to Mercury. Bepi Colombo was launched on a ten-year mission in October 2018 and will get to Mercury in 2021 with multiple flybys of Earth and Venus.

Professor Ernst Rasel from the Institute of Quantum Optics, University Hannover, reminded the audience that the

unique attributes of microgravity facilitated the creation of the Bose-Einstein Condensate (BEC) in space. It was first created during a sounding rocket experiment in 2017 and since then it has been produced regularly onboard the ISS.

Jason Williams, Research Technologist at NASA's Jet Propulsion Laboratory, outlined the premier benefit of a microgravity environment. Experiments can be performed on the ISS that are impossible to do on Earth. BEC is now produced on the ISS daily. The Cold Atom Laboratory onboard the ISS is the world's first multi-user facility for the study of quantum gases in space.

Sirisha Bandla, Government Affairs & Business Development Manager and Cody Knipfer Government Affairs Specialist both with Virgin Orbit organized the panel *Launch Tower Not Necessary: Could Responsive Launch Revolutionize Spaceport Infrastructure Needs?*. The panel discussed the opportunities and challenges of mobile launch, sea-launch, air-launch and spaceport operators.

The flexibility of mobile launchers has obvious military benefits. General Nina Armagno, Space Programmes Director, United States Air Force, asserted that space is a critical aspect in modern warfighting in LEO, MEO and GEO. Mobile launch facilities allow for a resilient and agile





solution not possible in traditional launch environments. In pursuit of flexible launch options, military needs may be procured from commercial launch services from for example Rocket Labs' new launch facility under construction in Virginia.

Karina Dress, CEO & General Manager, Mojave Air & Space Port, remarked that their licence acquired in 2004 covers General Aviation and Helicopter Traffic, Virgin Orbit (air launch to orbit) and Virgin Galactic (suborbital space tourism). Their remote location and restricted airspace is particularly suitable for military operations.

James Linter, Air Attaché to the US for the UK, spoke about Carbonite 2. A small satellite built in the UK and launched by ISRO's PSLV in 2018. It was built using COTs components and provides real time video from space to the cockpits of RAF pilots. Modern agile innovative private sector players are providing cost-effective build and launch solutions for commercial and military demands.

Justin Kugler, Vice President Made In Space, organized the panel *Transforming Future Mission Design Through In-Space Manufacturing*. A technology that is now moving from science fiction in to science fact. An experimental Additive Manufacturing or 3-D printing facility was first available onboard the ISS in 2014 and an operational one has been available since 2016. The 3-D printer was constructed by Kugler's California based company, Made in Space Inc. The benefits of manufacturing in space include reducing launch costs, payload costs and for sensitive devices minimise the risks associated with the tumult of launch and subsequent deployment. He went on to explain another project that his company with other partners, is currently developing. Called Archinaut, it is a satellite that will make part of itself in orbit. Eventually fabricating large scale structures such as antenna reflectors for communication satellites.

Raymond G. Clinton Jr., Associate Director, Science and Technology Office, NASA Marshall Space Flight Center, shared details of a technology demonstrator called Refabricator. A 3D printer that uses plastic material including that used to package and transport cargo up to the ISS, as raw material for the 3D printer. For example, it can turn plastic packaging into a new plastic spoon. This sustainable model that can recycle waste material will be key for extended space missions. The fabricator on the

ISS is currently undergoing testing and operated remotely from Earth.

NASA's Commercial Lunar Payload Services (CLPS) will engage the private sector to transport spacecraft or payloads to lunar orbit or the lunar surface. It is expected that additive manufacturing and Refabricator like technology will be incorporated in the CLPS programmes.

A profoundly significant theme of humanity's first steps into the interstellar space was the topic of the final SpS panel for IAC 2019 - *Interstellar Probe: Humanity's First Deliberate Step into the Galaxy by 2030*. It was organized by Ralph L. McNutt, Jr. Chief Scientist for Space Science, Johns Hopkins University. Travelling beyond the Sun's sphere of influence opens possibilities to understanding the local interstellar medium, mass distribution on a scale of a planetary system and the early formation of the galaxy.

As the Voyager, Pioneer and New Horizons spacecraft have shown, missions beyond the solar system take decades. NASA's Leon Alkalai outlined the challenges of launching spacecraft out of the solar system with suitable payload to collect data that could help answer those questions. Voyager 2 is leaving the Solar System at around 3.3 AU/year. An analysis of the Space Launch System (SLS) Block 1B indicates that it could provide the required delta-V for an Interstellar Probe. An Interstellar Probe proposed by the panel could reach a speed of seven to nine AU/year incorporating a Jupiter Gravity Assist.

High speeds are necessary to cover the large distances relatively quickly. The proposed mission architectures could cover the distance to Pluto in about four years. New Horizons encounter at Pluto took place at a relative speed of 14km/s, the Interstellar Probe encounters would occur at around 50 km/s and data transmissions over vast distance would be another challenge requiring extensive commitment from the Deep Space Network.

The Interstellar Probe is an ambitious mission that can trace its roots to the 1960s. A NASA funded detailed study is in progress. The panel discussed the science objectives, notional payloads and mission architectures for the Interstellar Probe. Michel Blanc, Professor, Institut de Recherche en Astrophysique et Planétologie, pointed out that, most of the Solar System is not known. The Interstellar Probe will allow us to see the Solar System from the outside.

IAF IDEA “3G” Diversity Day



In the frame of the IAF’s diversity initiative to promote and advance the principles of “3G” (Geography, Generation, and Gender) Diversity amongst a global space community, the IAF welcomed delegates to participate in the IAF Diversity Activities focusing on different diversity aspects and offering valuable networking opportunities to bring together the global space community.



Wednesday, the 23 October 2019, was again declared as IAF IDEA “3G” Diversity Day and began with the IAF IDEA “3G” Diversity Breakfast sponsored by Jet Propulsion Laboratory (JPL). The event was launched by a welcome of the IAF President, Jean-Yves Le Gall* and followed by an introduction from Moderator Mary Snitch, the Special Advisor to the IAF President (Diversity Initiatives)*. Larry D. James, Deputy Director of JPL, spoke on behalf of JPL and shared an exciting video about the role of diversity at JPL. The Breakfast session concluded with a 3-person panel featuring Rukmini Roy, Rosemary Davidson and Rachael McKee: 3 female engineers currently in their degree programme or very recently graduated. During the panel discussion the three women shared their experiences and addressed the important question of “What would you do to improve the diversity of the Engineering Workforce?”

The Luncheon, introduced once again by the IAF President Le Gall* and Mary Snitch* was dedicated to the award ceremony of the 2019 IAF Excellence in “3G” Diversity Award, given to the UAE Space Agency for its outstanding contributions to the fostering of “3G” Diversity within the space sector. The award was accepted by His Excellency Dr. Ahmad Belhoul Al Falasi, Minister of State for Higher Education and Advanced Skills Chairman of the UAE Space Agency.

As a valuable addition to the IDEA programme, the IAC 2019 featured on Thursday 24 October a Keynote by Rhoda Shaller Hornstein, retired from the National Aeronautics and Space Administration (NASA), on “A Girl in the Man-on-the-Moon Programme: Camaraderie and Discrimination in the Apollo Era”. Christian Feichtinger, IAF Executive Director, welcomed and introduced this special Keynote Session with Rhoda Shaller Hornstein telling her story of the highs of camaraderie and the lows of discrimination.

On Friday 25 October the IAC hosted a Panel and Roundtable with the Women of Aeronautics and Astronautics (WoAA) on the topic of: “The First Woman on the Moon: The Women Who Are Working to Get Us There”. Elena Feichtinger, IAF Manager for the Diversity Programme, welcomed the female space role models who spoke about their mission to provide support, empowerment, and networking opportunities for women and other minorities in the aerospace field, primarily focusing on university students. The second half of the session featured interactive roundtables, allowing for attendees to dialogue with speakers and brainstorm in small groups about how we can build a diverse aerospace workforce.

**Editor’s Note: At the end of the IAC 2019 Jean-Yves Le Gall’s presidency terminated and he became IAF Honorary Ambassador. Mary Snitch was elected as IAF Vice President for Communications, Publications and Global Conferences.*



10th IAF International Meeting for Members of Parliaments



The 10th IAF International Meeting for Members of Parliament (MoP) “*Opportunities and Challenges for Legislators in Space Exploration and Space Traffic Management*” was held on Sunday 20 October, as associated event to kickstart the 70th International Astronautical Congress (IAC), in Washington, D.C. The full-day meeting was composed of two sessions and 7 keynotes, and it brought together parliamentarians, heads of agencies and private sector representatives from around the globe.

Kendra Horn, Chair of the event and Chairperson of the US House Science Subcommittee on Space and Astronautics, and Isabelle Duvaux-Béchon, Head of Member States Relations and Partnerships Office at the European Space Agency and moderator of the event, welcomed the participants emphasising the critical role of space as an asset for our everyday life and the importance of continuous investments in the sector. The IAF President, Jean-Yves Le Gall reminded the audience how much the IAC has grown over the past years, and how the IAC continues to provide a regular and open platform where diverse opinions can be shared.

Jan Woerner, ESA Director-General, and IAF VP for Agencies, Parliamentarians and Ministerial Relations, highlighted the need for governments to address the challenges of New Space. The space domain is now populated by many commercial entities, and 70 countries are now active in the field, while the advent of mega-constellations and the expanding the space debris call for an urgent regulatory framework.

Klaus-Peter Willsch, Member of the German Bundestag and Chairman of the Aviation and Space Group, hosted last year’s Meeting and contended that not only Space activities and applications make modern lives possible but that Space data could help to inform the policymakers in their decisions.

John S. Langford - President of the American Institute of Aeronautics and Astronautics (AIAA) welcomed the Members of Parliaments as IAC 2019’s host organization. While, Mohammed Al Ahababi, Director-General of the UAE Space Agency and host of next year’s IAC, invited everyone to join him in Dubai for IAC 2020.





In the first keynote of the day, Sandra Magnus, IAC 2019 Local Organising Committee Chair and former NASA Astronaut, identified three phases of the commercialisation of space: the initial government-driven phase with no incentives for the private sector; the current phase, not yet fully organized, where technological innovation is facilitated by private sector; and finally the normalization phase where Governments will be just one customer amongst many.

In the second keynote, Hiroshi Yamakawa, President of the Japan Aerospace Exploration Agency (JAXA), outlined Japan's 60 year-long history of space exploration and international cooperation. He also announced JAXA's intent to cooperate with NASA on lunar exploration, including Japanese role in the lunar Gateway and human lunar landings.

During his keynote address, NASA Administrator Jim Bridenstine welcomed JAXA's announcement to engage with the Gateway, which aims to take humans back to the lunar surface sustainably using in-situ materials including water. The Gateway will be based on an open architecture that would facilitate the cooperation with commercial and international partners.

The first Panel of the day, "*Space Exploration*", was moderated by Jan Woerner, and it was composed of representatives of Space Agencies and Companies. Mohammed Al Ahababi, presented his Agency's accomplishments, in particular the development of its mission to launch a spacecraft to Mars in 2020, and the return of and its first astronaut after an 8-day stay on the International Space Station. Pascale Ehrenfreund, Chair of the Executive Board at DLR and incoming IAF President, emphasized the advantages of coordinating dialogue to help secure the growing need for regulations. They were followed by Sergei Krikalev, Executive Director for Piloted Spaceflight at Roscosmos and a Cosmonaut, who stressed the silver lining of the

duplication of services, at private and public level, using as example the important role of the Soyuz programme after the retirement of the Shuttle. Clay Mowry Vice President – Global Sales, Marketing & Customer Experience at Blue Origin expressed the company's long-term vision and cautioned that necessary legal frameworks should result from non-partisan debates and international cooperation; while Masami Onoda, Director of JAXA's Washington Office, reported the upcoming launch of the upgraded version of HTV-X, the transfer vehicle used by JAXA to supports the ISS. The final speaker of the panel, Christian Sallaberger - Chairman of the IAF Space Exploration Committee, reminded the attendees that although regulation is necessary, legislators should be mindful not to inhibit innovation or obstruct new trends.

In her Lunch Address, Dominique Tilmans, Honorary Senator of Belgium and President of EURISY, used practical examples to stress the benefits that Space can bring to our everyday life: she mentioned the PulsePoint AEDD (Automated External Defibrillator), a free mobile app that can be used to help cardiac arrest victims, and the use of high-resolution satellite images to detect deformations in infrastructures such as roads, bridges and buildings.

The afternoon portion of the meeting was opened by Kevin O'Connell, Director of the Office of Space Commerce at the US Department of Commerce, who dealt with the developing space economy and the need to address the challenges of Space Situational Awareness and Space Traffic management.

Simonetta Di Pippo, Director of the United Nations Office for Outer Space Affairs (UNOOSA), used her keynote to stress the importance of Long-term Sustainability of space. Since 1957, over 8750 spacecraft had been launched into space but only 7800 were registered, for this reason she urged all nations to participate in data sharing and help improve the practice of space object registration.

In the following Keynote, Carine Claeys, Head of Space Task Force of the European External Action Service (EEAS), returned to the theme of space being congested, contested and competitive. She asserted that urgent action is required to provide Safety, Security and Sustainability, and suggested that a new global agreement should be developed for space.

In the final Keynote of the day, Sarah Anyang Agbor, Commissioner in Charge of Human Resources, Science and Technology for the African Union Commission, provided a vivid picture of space activities in Africa. Of the 55 countries in Africa, 8 already have launched satellites and 11 are developing nascent space programmes. She outlined the importance for Africa to develop indigenous capabilities in space for the management of the environment and natural resources. As with all developing countries, partnerships and international agreements will determine the rate at which the space sector grows in the continent. Regulatory framework and comprehensive governance will determine the extent and speed by which benefits of space will reach the people in Africa.

The second Panel, “*Space Traffic Management*”, was moderated by Kai Uwe Schrogl, President of International Institute of Space Law (IISL). The session focused on how legislators will implement the 5 space treaties and principles given the increasing number of international and commercial actors in Space. The session was introduced by Christophe Bonnal, IAF Co-Chair of the joint IAF/IAA/IAL Space Traffic Management Working Group. He reminded the audience that space debris concerns were first expressed in 1971 and increase every day. Only 10% of the tracked space objects are operational spacecraft and the current level of compliance with existing guidelines, codes of conduct and best practices remain low. Peter Martinez, President of the Secure World Foundation,

described how we can enforce compliance with existing rules by pointing to the voluntary Long Term Sustainability (LTS) guidelines adopted by UNCPUOS in June 2019 and the set of “*Best Practices for the Sustainability of Space Operations*” established by the Space Safety Coalition. Wayne R. Monteith, Administrator of the Commercial Space Office at the Federal Aviation Administration (FAA), presented the challenges faced by the FAA to keep up, as the mega-constellations achieve their goal of 30,000 spacecraft in LEO. The US has 11 FAA-licensed spaceports, and with the launch of 62 Starlink satellites in May 2019 and more planned before the end of the year, computing safe launch windows is becoming increasingly complex. Reporting from the operator’s perspective, Elina Morozova - Intersputnik Head of International & Legal Service, expressed the importance of compliance with the ITU requirements and adhering to the agreed radio frequencies to prevent harmful interference. The session was closed by, Paulo Eduardo Vasconcellos, Director of Space Transportation and Licensing of the Brazilian Space Agency, who suggested as possible solution for STM was the creation of an organization similar to that International Civil Aviation Organisation (ICAO).

In her closing remarks, Chairwoman Kendra Horn categorized our journey to Space in three phases: Starting from humanity’s first steps in space, the initial phase, moving on to the current developmental phase, characterized by the solar system exploration and the constant human habitation of the ISS. She emphasized that the present phase still needs to be properly organized and that decisions taken now will have a lasting impact on Earth and in Space. The transition towards the third, normalization-phase will be diplomatically, legally, commercially and geopolitically challenging. Space is a critical infrastructure and international partnerships will be essential in defining a roadmap and priorities for a sustainable future for everyone.





IAF Committees



IAF Astrodynamics Committee

The Astrodynamics Symposium at the IAC traditionally is very interesting, competitive, and attracts many excellent papers to its nine sessions dedicated to Mission Design, Operation and Optimization, Orbital Dynamics, Attitude Dynamics, and Guidance, Navigation, and Control. At one of the sessions, the Breakwell Memorial Lecture was delivered by David Folta, an Aerospace Engineer in the Navigation and Mission Design Branch at NASA's Goddard Space Flight Center (GSFC) where he leads multiple NASA missions, chairs engineering review panels, and develops innovative technologies across the full spectrum of mission types. His lecture "Astrodynamics of Lunar and Cis-Lunar Missions" presented an overview of the advances in mission design approaches and techniques over the past 50 years, when a number of astrodynamics and engineers, both at NASA centers and universities, strived to determine innovative methods to not only achieve lunar landings, but to provide access to distinctive orbits about

the moon and in its neighboring environment. This lecture was a great success, and gathered over 150 attendees.

In 2019 the Astrodynamics Committee organized also its 10th International Workshop on Satellites Constellations and Formation Flying hosted by the Aerospace Centre of Excellence at the University of Strathclyde and chaired by Prof Massimiliano Vasile. For four days in June it gathered experts, researchers from science, mathematics and engineering based in research institutions, universities, and industries to discuss recent advances in the field of astrodynamics applied to satellite constellation and formation flying.

The Workshop was a mix of regular sessions, and key notes, including some virtual presentation via Zoom. An expo area was available to companies, together with a dedicated facility to run demos and tutorials. More information at <https://www.strath.ac.uk/engineering/iwscff/>

Astrodynamics Advances Highlights For 2019

Laureano Cangahuala, Jet Propulsion Laboratory, California Institute of Technology, USA

2019 began with the New Horizons spacecraft successful flyby of Kuiper Belt Object 2014 MU69, referred to as "Ultima Thule," a primordial compact binary. This is the most distant object ever visited by a spacecraft. Prior to the event, the project conducted an impressive stellar occultation campaign across several opportunities in order to improve knowledge of the target ephemerides, size, and shape, which in turn aided mission planning significantly.

On 3 January the Chinese *Chang'e 4* (嫦娥四号) spacecraft, launched in 2018, made the first soft landing on the far side of the Moon in the Von Kármán crater in the South Pole-Aitken basin. From there it deployed the *Yutu-2* (玉兔二号) rover, and has maintained contact with the Earth via the *Queqiao* (鹊桥) relay satellite that is deployed in a halo orbit around the Earth-Moon L₂ point.

There were other significant flight dynamics events related to Lunar exploration this year. In February, the Israeli organization SpaceIL launched its *Beresheet* (ברישית) lander, and in April successfully reached Lunar orbit. Later that month its attempt to achieve the first privately funded landing failed in the final minutes on approach to the surface. In August, *Chandrayaan-2* (चंद्रयान 2) reached lunar orbit, and deployed the *Vikram*

(विक्रम) lunar lander. Upon final descent, the lander deviated from its planned trajectory within 2 kilometers from the surface; post-event imaging confirmed that it had achieved a hard landing. The orbiter continues its scientific mission.

With regard to small body exploration, *Hayabusa 2* (はやぶさ2), which arrived at near-Earth asteroid 162173 Ryugu in 2018, performed its first sample acquisition on 21 February. On 5 April, *Hayabusa 2* released an impactor and created an artificial crater on the asteroid surface. Deploying a reflective target marker near the crater, touchdown and sub-surface sampling took place on 11 July. *Hayabusa 2* will begin its low-thrust return to Earth at the end of the year. In the meantime, the OSIRIS-REx spacecraft has been conducting extensive surveys at the near-Earth asteroid Bennu in preparation for sampling activities in 2020.

In addition to the above advances in the state of the practice, there has been much astrodynamics research involving the infusion of artificial intelligence techniques into trajectory optimization and orbit determination. Algorithms of particular interest include machine learning (including reinforcement learning, deep learning, neural networks, and on-board

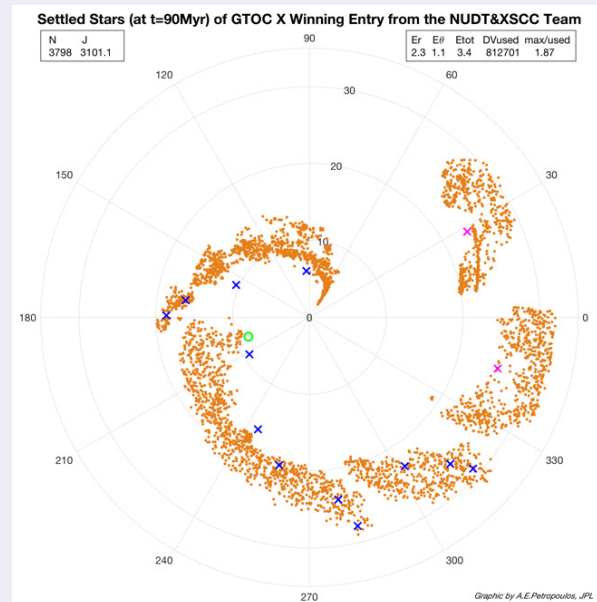
mission design). Progress is also being made in the area of Space Situational Awareness. Astrodynamics continues to inform the maturation of categorization of risk assessment paradigms, algorithms, and techniques, the mitigations of such risks, and Space Traffic Management in general. Other growth areas include research into Earth-Moon transfers, particularly with Near Rectilinear Halo Orbits (NRHO), motivated by the proposed Lunar Gateway.

Finally, the Jet Propulsion Laboratory hosted the 10th edition of the Global Trajectory Optimization Competition (GTOC X). GTOC was started in 2005 by

the European Space Agency's Advanced Concepts Team as a way to foster innovation in optimization of interplanetary trajectories and cross-fertilization of ideas between researchers in optimization and in astrodynamics. The ambitious GTOC X task was to achieve interstellar settlement in as broad a manner as possible with minimal propulsive velocity change. Congratulations to the team led by the National University of Defense Technology and the Xi'an Satellite Control Center (NUDT-XSCC), who won with a phenomenal solution. A workshop presenting the methods and results from the competitors was held in a special session of the AAS/AIAA Astrodynamics Specialist Conference.



Left: Kuiper Belt Object 2014 MU69 from the New Horizons Spacecraft (credit NASA / JHUAPL / SwRI)



A plot of the winning GTOC X solution (credit NUDT / XSCC)

The reporting was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004).

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IAF Committee on Near Earth Objects (NEO)

The Technical Committee (TC) on Near Earth Objects (NEOs) saw a change in leadership last year. Alan Harris retired and opened up the Chair position. Alex Karl was elected as new Chair and started his term as from IAC 2018.

Alex' vision is to increase the coverage of planetary defense and other NEO related topics such as asteroid mining, capacity building for decision makers, and communication with the general public at the IAC to complement the work done in other committees that address a subset of NEO topics, such as the IAF Space Exploration Symposium, the IISL Colloquium on the Law of Outer Space, and the IAF Astrodynamics Symposium.

The goal is to raise awareness among the global space community about the ongoing work within the NEO and Planetary Defense communities and to get more people, especially students and young professionals interested and attracted to the topic.

The TC further aims to establish a pool of expertise to act as authority and point of contact in particular for national and international bodies and the media, for authoritative information and advice on NEO related topics.

Since IAC 2018, six new members and experts were added to the committee. The aim is to have a balanced membership in terms of the "3G" (gender, generation, geographical distribution) and representation of individuals with various backgrounds and specialties from agencies, industry, academy and organizations that can contribute their expertise to the knowledge base of the TC in various NEO related areas. Examples of such areas are discovery, characterization, (deflection) modeling, mission design, geopolitical and legal considerations, economics, impact consequences, disaster response, impact risk assessment, decision to act, public education and communication.

The main outcomes of the TC meeting at the IAF's Spring Meetings in March were the election of Nancy C. Wolfson as Vice Chair of the TC, as well as the decision, based on Ms. Wolfson's suggestion, that the TC should have its own technical paper session at future IACs in order to help create, build and broaden a NEO community at the IAC. The proposal to add a symposium in the E category and a session was discussed and tentatively accepted by the IAF under the condition that a time slot can be found. The challenge is now to find a suitable slot in the busy schedule to make that happen.

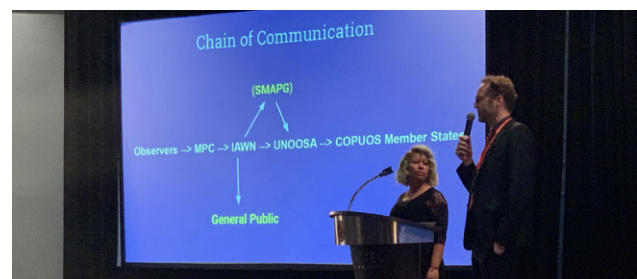
It was an eventful year for the NEO community. NASA's Osiris Rex as well as JAXA's Hayabusa 2 are at asteroids Bennu and Ryugu respectively, and provided stunning close-up views of these objects. Both are sampling missions that will return samples back to Earth.

NASA recently announced funding of the Near-Earth Object Surveillance Mission (NEOSM), aka NEOCam, a space-based infrared telescope designed to survey the solar system for potentially hazardous asteroids from the Sun-Earth L1 point. Meanwhile ESA's HERA mission is awaiting funding at ESA's Ministerial Meeting end of November. The funding for the European contribution to an international double-spacecraft mission to demonstrate our ability to deflect asteroids would mean significant progress in building our confidence towards utilizing asteroid deflection techniques.

During the Northern hemisphere summer months, the International Asteroid Warning Network (IAWN) organized a campaign to observe asteroid 1999 KW4 in order to exercise the observing resources and characterization capabilities that may be applied to a near-Earth object on a reasonably short timescale. The asteroid was observed by several observatories from around the globe.

The highlight of the year for the NEO community was the biannual Planetary Defense Conference (PDC) that took place this year in College Park, Maryland from 29 April – 3 May and brought together almost 300 experts and participants. Highlight was the tabletop exercise where conference participants were presented with a hypothetical asteroid threat and asked to consider and recommend specific actions that should be taken as the threat evolved. Goals of the exercises are to illustrate how an actual threat of impact by an asteroid or comet might look and might evolve and help understand ways to improve our response to such threats.

For IAC 2019 a Special Session 'Get ready to protect Earth from asteroids – Planetary Defense in your hands' was submitted and accepted to bring this exercise to the IAC audience. Although shortened to fit the session, it allowed the audience to participate via polls throughout the exercise to interact with the scenario while an expert panel discussed the context. The session took place Monday 21 October. It has been moderated by Vice Chair Nancy C. Wolfson and the panel consists of Bill Nye (The Science Guy), cosmonaut Dorin Prunariu, NASA's Planetary Defense Officer Lindley Johnson, GMV's Mariella Graziano and TC Chair Alex Karl.



Vice Chair Nancy C. Wolfson and Chair Alex Karl presenting at the PDC.

IAF Earth Observations Committee

During 2019 the EOC met in Paris in March where the EOC session chairs reviewed and selected a wide range of papers for the 2019 IAC, with all 7 sessions finding outstanding papers for the meetings.

As of the Paris meeting, the EOC has 28 members and is actively looking for new members to enhance its age and gender distribution, as well as to improve the ratio of non-European members.

During the EOC meeting in Washington several new members joined the committee, and the members also expressed a wish to increase beyond thirty members which was agreed by the EOC Chairs.



EOC members attending the IAC in Washington, D.C.

Apart from the formal sessions the committee also arranged many additional activities for the IAC, involving considerable effort to not only discuss and agree on topics, but also in finding the speakers and panelists to take part.

Following the highly successful IAC in Bremen the EOC prepared a range of events specific to Earth Observation and its worldwide role in society at the IAC in Washington.

These events kicked-off with the B1.1 session at which, as in previous years, CEOS was invited to provide a keynote presentation which this year was given by D. K. Das, Director, Space Applications Centre, ISRO. The IAC week was concluded with another key note presentation in session B1.6 on 50 Years of Earth Observations: The Contribution to Sustainable Development Goals and Plans for the Future by Lawrence Friedl, Director, Applied Sciences Programme, NASA

As well as these key note presentations there were also a series of dedicated events arranged by the EOC together with the GEOSS sub-committee.

The 7th plenary session of the IAC “Harnessing Citizen Science for the Future of Earth Observation” examined how crowdsourcing and citizen science contribute to Earth remote sensing and the challenges this presents in carrying out these type of studies.

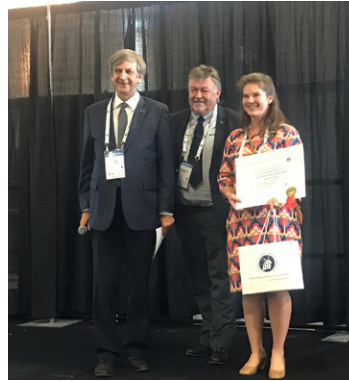
The plenary moderators were Masami Onoda, Director at Japan Aerospace Exploration Agency (JAXA), Washington, D.C. Office, and Kristin Wegner, Project Manager at GLOBE Implementation Office, UCAR, Japan with speakers from The United States, South America and Europe.

Three special panel sessions were also arranged starting with a panel discussion on our Home Planet 2030 on the role of Earth Observations in studying our planet, organized by Jim Graf, Deputy Director for Earth Sciences and Technology, NASA Jet Propulsion Laboratory (JPL) and Harry Cikanek, Director, National Environmental Satellite, Data, and Information Service (NESDIS), NOAA. The session was overseen by Michael H. Freilich, the retired Former Director of the Earth Science Division, NASA, with speakers from major Space agencies and organizations of the United States, Europe and Japan. The second special session covered EO as a game changer in the way we see the world. The session was organized by Agnieszka Lukaszczyk, Senior Director of European Affairs, Planet with speakers from Space agencies and industry from the United States and Europe. The final special session was on using open Space data in developing countries. It was organized by Jeanne Holm, University of California, Los Angeles (UCLA), with speakers from the United States, Africa and South America.

Two IAF Global Networking Forum (IAF) events were arranged the first on EO as a pillar of the space economy and, perspectives of industrial policy. This was organized by the Italian Space Agency (ASI) and moderated by Maria Cristina Falvella (Head of Strategy and Industrial Policy, Italian Space Agency), with a panel composed of leading Space Agency and Industry leaders from the United States and Europe. The second IAF looked into how Space Earth Observation is supporting the UN sustainable development goals 2030 agenda. The IAF was organized by the Space Generation Advisory Council (SGAC) and European Space Agency (ESA), moderated by Isabelle Duvaux-Bechon (Head Member States Relations & Partnerships Office, ESA) with speakers from the UN, Africa and Europe.

All these events are the result of considerable effort by our EOC members who should be congratulated on the quality and breadth of the different events arranged this year for the 70th IAC.

During the Washington IAC the Interactive Presentation session saw eight papers presented covering a wide range of topics. The paper by Ms. Elise Knutsen, NASA, United States on ‘Microwave observations of mesospheric ozone loss over Antarctica associated with particle precipitation’ was selected as best paper in the Category B on Applications and Operations.



Ms. Knutsen receiving her award from Prof. Koudelka and Mr. Bonnal for the best interactive presentation in the Category B (Applications and Operations)

IAF Enterprise Risk Management Committee (ERMC)

The Committee for “strategic risk management in space and defence programmes” met during IAC 2019 in Washington and featured a key note speaker this year, former French Air Force major general Pascal Legai, today Senior Adviser to the Earth Observation Programmes Director of the European Space Agency. Legai presented an overview of what he believes, based on his personal experience, are the challenges and opportunities awaiting the space sector in the security and defence area. The following focuses on Mr Legai’s main messages:

Space systems offer by nature global coverage and near real-time data delivery. They can serve various policies, including security and defence, depending on characteristics, such as orbit and sensor-types. In general, all systems have a potential dual-use, like the different components of the European Space programme: Galileo (Positioning/Navigation/Timing, PNT) and its “Public Regulated Service” (PRS), more accurate, reliable and protected, for authorised users only is a good example; Copernicus (Earth Observation) and its security service; Space Surveillance and Tracking (SST); Governmental satellite communications (Govsatcom).

Europe and its Member States have today the second largest space budget in the world after the United States, influencing the global space landscape, and its security and defence dimensions. The main issue consists in determining the proper balance and burden sharing of space security and defence competences between a multinational organization and its member states for which these domains are mainly of national sovereignty.

From this perspective, the European Space Policy aims at contributing to the crucial Strategic Autonomy to support the European political credibility in the field of Security and Defence, through a coordinated dual approach between the European Union (EU), its Member States (MSs) and the European Space Agency (ESA).

This major idea is supported by three main guidelines:

Anticipating risks before they become major threats (containing the criticality level),

Very High Resolution Earth Observation linked to precise positioning allow to detect, recognise, identify and analyse at an early stage potential risks thanks to change detection technics and use of indicators of irregular activities. Secure communications allow in a second step to deliver relevant products and services to end-users in due time. For instance, the monitoring of migration fluxes from inland departure points, or the development of nuclear programmes for military purposes, are illegal activities that can, thanks to space technologies, be anticipated. This information is useful for political and diplomatic actions or military intervention. Integrated services merging EO-PNT-Telecommunications, and cloud-based downstream applications, to give raw data some added-value, are of course of paramount importance in the end to end cycle from sensor to end-user.

Building resilience capacity to adapt posture to any unexpected situation,

In order to meet a wide range of existing security and defence needs, but mainly to be in a position to react to any unforeseen event, R&D-design-development phases and resulting space capacities should include a large range of options in terms of electromagnetic spectrum, sensor resolution, revisit times, level of protection of space/ground segments, on-board and ground processing to speed up availability of relevant data through secure distribution networks appropriately dimensioned.

Sharing responsibilities between European space actors (EU, MSs, ESA) for a consistent coordination in the field of security,

The European Commission and EU Member States resolutely took a strong security and defence orientation to protect the Union and its citizens, but also to strengthen the Union capability to be a credible global actor in this area, where space plays a significant role. The EU Global Strategy, the Space Strategy for Europe, the European Defence Action Plan with relevant implementation mechanisms and a dedicated European Defence Fund, all these initiatives have helped shaping this evolution since 2016. The Space Regulation in April 2019 confirms the need for coordinating space activities, especially in such a sensitive domain. In this respect, ESA has the necessary technical skills to accompany this quite normal evolution, now relying on the political decision of ESA nations.

As a conclusion, it appears that space policies, similarly to any policy, entail risks and opportunities. Regarding risks, on the one hand, economic priorities such as internal market, growth, job creation, maintenance of R&D and industrial base, geo-return, all constitute essential and legitimate objectives whereas they are not necessarily compatible with end-users satisfaction. On the other hand, the security and defence challenges Europe is taking on board today require a close coordination between the European Union and its Member States to prove cohesion, solidarity and will. Within this European political context, Space offers an exceptional opportunity of consensus and concrete achievements between the three major European space actors: The European Union (EU), Member States and the European Space Agency (ESA). In particular, in the field of civilian security (environment, natural disasters, humanitarian aid, food and water supply, pollution,

illegal activities,...), cooperation with national space agencies or international organizations (e.g. UN) on areas of common interest would allow fruitful synergies. Within the space and security domain, the establishment of a legal framework internationally agreed upon, appears fundamental to use outer-space for exclusively peaceful purposes and in a totally safe way, notably by cleaning space from all debris following a “COP 21” model.



Dr Pascal Legai

In this respect, ESA with a sound 45-year experience in space research, development, sciences, applications, can clearly contribute to meet increasing security needs depending on its Member States’ decision. From a European perspective, all space actors provide varied know-how to build a credible strategic autonomy, in other words the European capability to act in the full spectrum of evolving needs, and to forge effective international partnerships. Industry, SMEs, start-ups are key partners as well, to translate changing security and defence demand into appropriate business model and innovative technology solutions, resulting in space data and services. User-wise, it is important to provide tailored services, which can be directly integrated in the working environment with the indispensable cloud-based processing capability and providing a secure context.

All the above contribute to help transform security risks into opportunities in a collaborative manner.

The committee members highly appreciated the Keynote speech and a similar format will be considered for future meetings as it triggered a debate on the risks in the space defence area, and all participants were able to express their views on this theme.



IAF Space Education and Outreach Committee (SEOC)

Overview of the Past Year

The Space Education and Outreach Committee (SEOC) worked throughout 2018 and 2019 to plan for excellent support to the 70th International Astronautical Congress (IAC), which was held in Washington, DC on October 21-25, 2019. We have already started our preparation for IAC 2020 to be held in Dubai, UAE.

At the 2019 IAC, we were happy to see the results of the hard work that went into planning and coordinating our technical sessions, along with facilitating professional development and STEM Engagement opportunities for students and educators. Below are some of our committee highlights:

The SEOC received a record number of abstracts for its sessions. Members participated actively at the IAF Spring Meetings in Paris and selected the best abstracts representing diverse authors and topics. They ensured that the E1 Space Education and Outreach Symposium and E2 47th Student Conference at the 2019 IAC offered a wide variety of presentations from primary school projects to nationwide outreach campaigns.

The SEOC committed to more actively support the IAF communications, by preparing a short SEOC related report for the IAF Newsletters that are distributed within the IAF community.

The 2019 Educators Professional Development Workshop was sponsored by the International Space Education Board (ISEB), IAF and SEOC. It was a full day of training, with talks, curriculum sharing, and hands-on sessions. Participants were exposed to a wide variety of resources, including the GLOBE Citizen Science Programme, CloudSat, CanSat, the Tree-Height Project, the ZICA Project, and ECLIPSE.

During the 2019 IAC, the collaborative efforts of the SEOC, ISEB, Space Generation Advisory Committee (SGAC), and other stakeholders, such as the American Institute of Aeronautics and Astronautics, the Space Grant Consortia, International Space University, and Students for Exploration and Development of Space were shown, as they supported NASA in a College Broadcast, entitled “NASA Presents Space and STEM – How Do You Fit In?” It had a small targeted on-site audience and a virtual global audience.

NASA TV broadcast this event “live” and posted it on YouTube and Facebook. There were “Watch Parties” held across the United States and abroad, which were coordinated in advance. This was an effort to extend components of the IAC beyond the Washington, DC Convention Center and increase space and STEM awareness.

The Student Programme was expanded to include two STEM Engagement Days, where over 600 middle school students were invited to converge upon the DC Convention Center and participate in activities facilitated by 12 STEM Organizations. These activities took place inside the International Student Zone (ISZ) and in the corridor area, immediately outside the ISZ. During our preparation for the IAC, we expected to see lots of orderly chaos and students having fun, while learning at the Congress. These students also had the opportunity to see and talk to astronauts during the astronaut panels that were held during each of these STEM Days.

The Student Programme also included a Young Career Panel, which was held on 22 October, entitled “STEM Careers: Today and in the Future.” Panelists represented the SGAC, IAF Workforce Development-Young Professionals Programme Committee, and NASA Office of General Counsel, representing Space Law.

We collaborated on crafting the Next Generation Panel and this year’s panelists showcased their ideas at Plenary 7: 10th Anniversary Next Generation Plenary: “Harnessing Citizen Science for the Future of Earth Observation” on 24 October.

General Changes to the Committee

Several nominations have been received for membership into the SEOC, which were reviewed and voted during the regular SEOC meetings (in Paris during the IAF Spring Meetings and in DC during the IAC).

New Developments in the Field of the Committee

The SEOC continues to make a conscious effort to be more collaborative, by increasing its engagement with stakeholders and sister committees. We are seeing successful results, which are mutually beneficial.

IAF Space Propulsion Committee

The Space Propulsion Committee addresses sub-orbital, Earth to orbit and in-space propulsion. The general areas considered include both chemical and non-chemical rocket propulsion, air-breathing propulsion, and combined air-breathing and rocket systems.

Typical specific propulsion categories of interest are liquid, solid and hybrid rocket systems, ramjet, scramjet, and various combinations of air-breathing and rocket propulsion and nuclear, electric, solar and other advanced rocket systems. The Committee is concerned by component technologies, the operation and application to missions of overall propulsion systems and unique propulsion test facilities.

Overview of the past year

Spring meeting was the occasion Space Propulsion Committee members to meet altogether and prepare IAC 2019 where, over 260 abstracts submitted, 166 abstracts were accepted including 35 interactive presentations.

Space Propulsion Symposium, C4, is expected to be very successful in Washington, D.C. In addition to the classical presentations during the 10 sessions and the Interactive session, 5 keynotes will be presented covering topics of Large Liquid Propulsion, Solid Propulsion, Electric Propulsion and Air Breathing Scramjet Propulsion.

We have also proposed a Highlight Lecture “A Small Step, A Giant Leap, and then Soar: Pioneering Space Propulsion for the Future of Space Flight” which, unfortunately, has not been selected at the end (only 3 selections over 18 propositions).

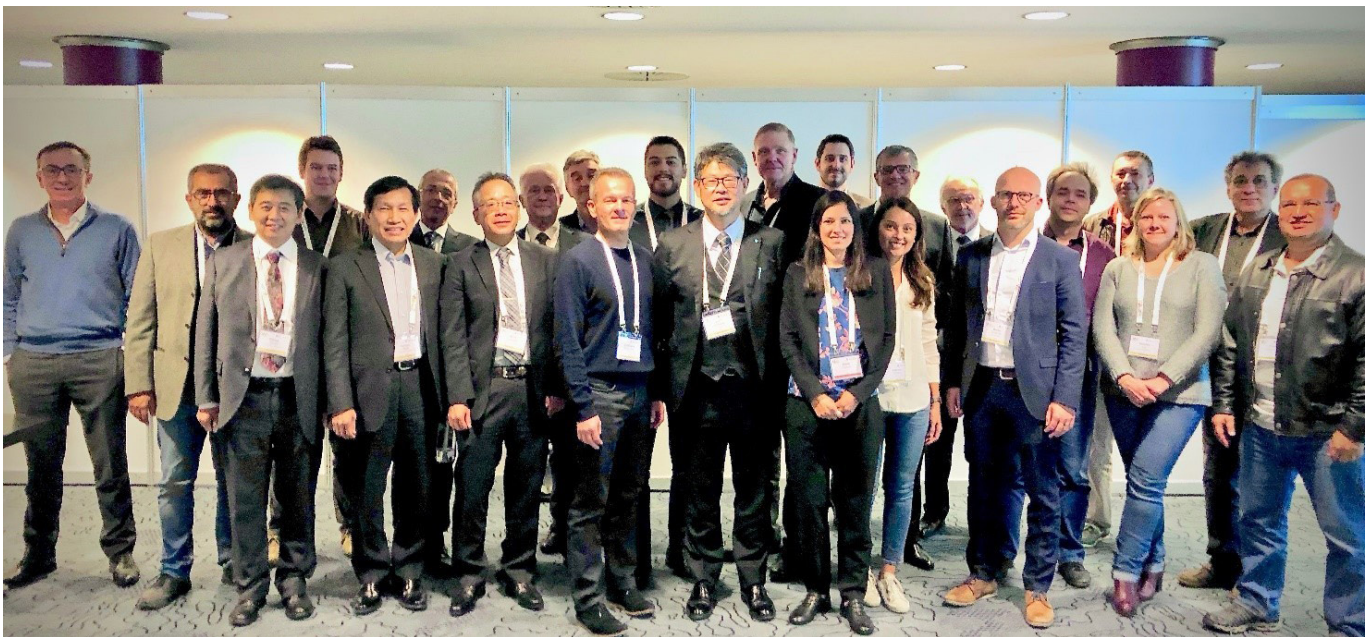
General Changes to the Committee

Following the election, from IAC 69th, Christophe Bonhomme (CNES, France) is the new Chair, and Vanessa Vial (Safran Aircraft Engines, France), Elena Toson (T4i, Italy), George Schmidt (NASA, United States), Giorgio Saccoccia (ESA, The Netherlands), Riheng Zheng (CASIC, China) are the Vice-Chairs.

New developments in the Field of the Committee

The IAF Space Propulsion Technical Committee is always looking to expand its membership toward a better representativeness of the whole range of age, country and skills with a good balance between women and men and between Academy, Agency and Private Company.

This year 2020, we will apply the new session structure (for 71th IAC) on which we worked in 2018 and 2019. This should bring a better repartition of propulsion topics between our C4 sessions.



IAF Space Transportation Committee

Highlight Report 2019

The Space Transportation Committee (STC) addresses Launch Vehicles in service or in development, Launch Services missions + operations and facilities, Upper Stages + Space Transfer + Entry & Landing Systems, Future Space Transportation Systems technologies, Future Space Transportation Systems verification and in-flight experimentation, Small Launchers concepts and operations and Space Transportation Solutions for deep space missions. As a special topic within the IAC 2019 related to the 50th anniversary of the Apollo 11 moon landing the STC addressed the creation of safe transportation systems for sustainable commercial human spaceflight describing the development and operations of critical systems of the Apollo programme as well as the heritage the Saturn 5 Rockets systems on modern rockets.

Overview on the past Year

IAF Spring Meetings Paris

The IAF Spring Meetings was the occasion for the STC members to select the papers for the IAC 2019 and to start the preparation of the IAC 2020 by defining the D2 symposium sessions. 93 papers were selected by the STC members for an oral presentation during the IAC 2019 in Washington, D.C., USA. Further 2 Key Notes were proposed: Falcon Launch Vehicle Lessons Learned and Reusability in session D2.1 and Lasting Developments from Apollo and Saturn V in session D2.9. 17 papers were selected for an interactive presentation. For the IAC 2020 in Dubai 8 standard sessions were defined for the D2 - IAF Space Transportation Solutions and Innovations Symposium with the recurring description from the past IACs. One

special session was defined for the D2 symposium considering the location of the IAC 2020: Emerging Global Space Ventures. This session D2.9 will describe developments in countries that have government or commercial space programmes which are new or emerging within the global picture, including space transportation systems or spaceports either under development or recently deployed. Such it is expected by the STC members that a high number of papers out of the Arabian region will be submitted and therefore a high attention will be obtained during the last day of the IAC.

IAC 2019 Washington

The STC finalized the organization of IAC 2019 in Washington, D.C. in the committee meeting held on Sunday, October 20 within the Convention Center in Washington. One difficulty for the D2 Symposium was the late information that the committee members from China as well as the presenters will not be able to join the IAC due to visa difficulties. So a lot of extra effort was needed in order to ensure that 2 chairs and 1 rapporteur are available for every STC session and that enough presentations are ready for presentation.

IAC 2020 Dubai

The final D2 symposium programme for the IAC 2020 was agreed during the symposium meeting. As described above the description of the session D2.9 was adopted towards the Arabian region. The STC is looking forward to an interesting and fruitful IAF Spring Meeting in Paris considering the lessons-learned from the IAC 2019. Especially the positive feedback from the Keynote presentations and the improvement proposals for the IP session will be considered.



General Changes to the Committee

In order to align with the latest IAF Terms of Reference (ToR), the ToR of the STC was updated in spring 2019. The major change relates to the election of the chair and the co-chairs as well as the election period. Such 3 chairs lead the STC. Each of them has a period of 3 years. A new chair needs to be elected during the spring meeting 2020 as the actual chair person, Markus Jäger will arrive at the end of his period.

In frame of the IAF Spring Meeting one new expert was elected within the STC.

In frame of the IAC 2019 3 new members were elected within the STC. 2 members dropped-out of the committee due to changes in their professional career.

In order to foster the exchange within the STC the LinkedIn and WhatsApp groups were adapted to the actual membership list of the committee. It will be checked during the IAF

2020 spring meeting which communication platform is the most appropriate to ensure permanent exchange and such knowledge transfer of the STC.

New Developments in the Field of the Committee

As seen out of the paper submission for the IAC 2019 2 main area of interest currently exist within the Space Transportation community: Deep space exploration based on heavy launchers and the need for affordable and flexible transportation solutions for small payloads. For both interest areas the question of re-usability is one of the main points to be answered in future. Such it is one important task for the STC to extend the list of members by members from companies like SpaceX, Blue Origin and RocketLab as leaders in the field of re-usability. Another important evolution task for the STC is the integration of members from emerging space nations like Brazil. Also we lack on Students in our committee.

IAF Subcommittee on the Global Earth Observation System of Systems (GEOSS)

The past year has been one of great collaborations and exciting innovations for the GEOSS Subcommittee. The Subcommittee expanded its long-term collaboration with the intergovernmental Group on Earth Observations (GEO). Gilberto Câmara, the GEO Secretariat Director, at our March meeting described his vision for future international collaborations, in which space agencies downlink the Earth-related data acquired from space, airborne, and in situ platforms to the cloud, and make the data available to everyone, everywhere around the Earth. Also, the IAF is a participating organization of the GEO. The GEOSS Subcommittee is coordinating/supporting IAF's representation in the 2019 GEO Plenary this year as it has done for the two previous years.

GEOSS completed its first three-year partnership with IAF's Young Professionals Programme Committee. This partnership was dedicated to exploring and sharing the benefits and amazing results of Citizen Science. The basic theme demonstrated to the members of the IAF what scientific advancements can be performed by ordinary citizens with the proper tools and guidance. The first year of the collaboration, the two committees conducted a IAF Global Networking Forum (IAF GNF) at IAC Adelaide. Last year at

IAC Bremen, together the committees piloted a IAF Global Technical Session (GTS), and this year at the Washington, DC IAC, they will conduct a Next Generation Plenary on the subject. The two organizations are discussing the possibility of another three-year collaboration devoted to the scientific benefits and training opportunities of cubesats. This collaborative effort might extend to two other committees: Education and Small Satellites. The thrust would cover technology, STEM, training, and science that comes from the use of cubesats and smallsats.

The GEOSS Subcommittee redirected the emphasis of one of the technical session toward the subject of big data, cloud processing, and artificial intelligence/machine learning as tools to help facilitate ingesting, processing and distributing critical Earth-related data. In all, the GEOSS Subcommittee facilitated or participated in four special sessions. 5 Global Network Forums, and in 6 technical sessions.

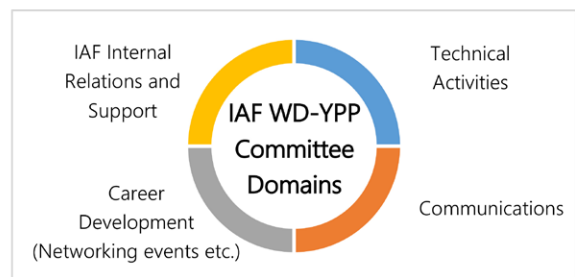
The Subcommittee is next exploring the general trend toward using small satellites and constellations for environmental observations and how this capability can be highlighted at the next IAC.

IAF Workforce Development-Young Professionals Programme Committee (WD-YPP)

WD-YPP Committee Highlight Report 2019-20	
Committee	IAF Workforce Development-Young Professionals Programme Committee
Goal/Motive	Workforce development, career development and guidance to young professionals from international space community.
Leadership	One Chair and Four Vice Chairs
IAF Information	http://www.iafastro.org/committees/workforce-development-young-professionals-programme-committee-wd-ypp/



Members from around the world (Diversity)



Each domain is taken care by its vice chair

An Overview of the Year

The IAF Workforce Development-Young Professionals Programme Committee has continued to work throughout the year to create a high quality programmes made specifically for young professionals at the IAC. The different events are all designed to be interactive, informative and inspiring – mainly for the YPs at the congress but also for the ones that couldn't make it to Washington, D.C. this year.

A new leadership team has taken over at the IAC in Bremen, see below, and has worked tirelessly to accomplish a seamless transition without sacrificing the quality of the YPP.

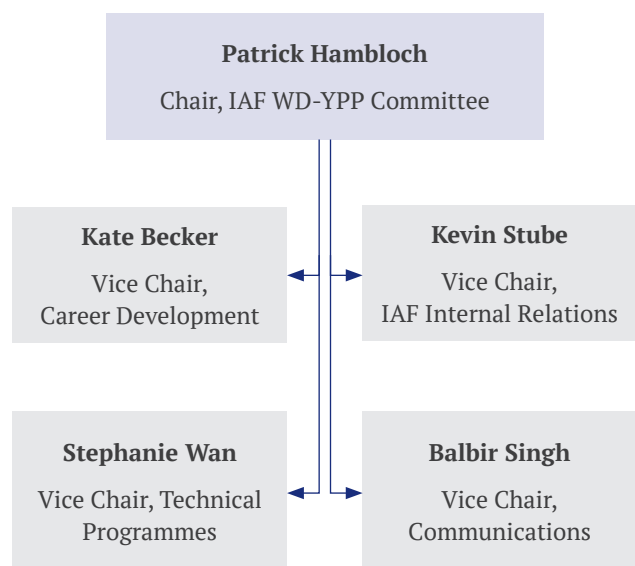
The overall committee consists of four different teams:



Each committee member contributes to at least one of those four teams. Together the teams are responsible for the YPP experience that is part of the IAC for more than a decade. To achieve the wealth of different topics, the WD/YPP committee regularly works with other committees like SEOC, GEOSS, EIC, and IPMC, to name just a few.

General Changes to the Committee

IAF Workforce Development Young Professional Programme Committee (IAF WD-YPP) welcomed new leadership (2018-21):



News Developments

- IAF WD-YPP committee has also continued to join hands with the SEOC on the workforce development subcommittee having members from both and to introduce workforce technical sessions.
- The structure of news blasts and other communication methods have been revived once again to make them reader friendly, crisp and informative.
- The committee has also approved the development and release of a YP Newsletter, a quarterly magazine exclusively for young professional and students. The first issue has been scheduled to be released after the IAC.
- The committee has also focused on joining forces with international organizations like SGAC and ISU for more capacity building events benefitting young professional and students.

Developments related to IAC 2019

For the 2019 IAC, the IAF WD-YPP Committee has prepared the following events in Washington, D.C.

- Cross Cultural Workshop 2019.
- IAF IPMC Workshop 2019 (co-organized with the IPMC).
- Networking Event “YP panel on IAF Opportunities”.

- Global Technical Sessions – Space Communications and Navigation, Student Team Competition, Small Satellite Missions, Human Spaceflight, Entrepreneurship Around the World.
- Networking Event “Industry Panel: The Moon”
- IAF Global Networking Forum – NASA YP Town Hall (Speaker is NASA’s Administrator Jim Bridenstine)
- IAF-SGAC-ISU Joint Networking Reception.
- Next Generation Plenary “Harnessing Citizen Science for Future of Earth Observation”

ESL, YSL Award winners

The committee is helping with the selection process of IAF’s Emerging Space Leaders Programme. Congratulations to 25 selections from 2019 applicants. They will travel to Washington, D.C. in October 2019 to participate in the IAC and have the opportunity to extend their network, gain knowledge and meet space experts.

The committee also helps in the selection process IAF’s Young Space leaders Programme. Congratulations to all five of them! They will also travel to Washington, D.C. in October 2019 to attend IAC Gala Dinner as guests of IAF president and IAC registration fees will be waived off for the year of their induction.

IAF Honours and Awards Committee (HAC)

Per mandate of the IAF President, Jean-Yves Le Gall, the HAC two years ago embarked upon an in-depth review of the Terms of Reference (TORs) of IAF awards, in order to ensure that they were clear enough to everybody, both inside IAF and even more importantly to the outside world so that the messages these awards sent to the space community were received with their full, strong and significant value. To that effect, the HAC started to review those which it is directly responsible for, based on the following guidelines : clear and distinctive description of eligibility for each award, clear description of the evaluation process, elimination of duplication in one document, elimination of inconsistencies between the documents of an award, same format for all TORs and same wording in the documents of an award.

Cooperating with the Space Education and Outreach Committee (SEOC) and the Industry Relations Committee (IRC), the HAC in the last year completed the review and update of 6 Awards TORs : the IAF World Space Award (HAC), the Allan D. Emil Memorial Award (HAC), the IAF Hall of Fame (HAC), the IAF Distinguished Service Award

(HAC), the Luigi G. Napolitano Award (SEOC) and the IAF Excellence in Industry Award (IRC). It is organizing a simple and instrumental evaluation matrix for each award to keep transparency and objectivity of its evaluation activity, and also is checking the consistency with other related IAF documents including the IAF Homepage.

In order to be as comprehensive as possible the IAF Vice President for Honours and Awards in charge Seishiro Kibe and the HAC Chair Pierre Bescond have called upon the other Awards Committees chairs to similarly revisit their TORs and update them, and also study the possibility of organizing their own evaluation matrices.

Last but not least, the IAF Secretariat produced a chart summarizing the criteria for all awards and describing the organization around them. This IAF Awards Overview Table can be found on the IAF website under ACTIVITIES/HONOURS & AWARDS.

Pierre Bescond
Chair of the Honours and Awards Committee

IAF Secretariat Activities Report

Preparation and Site Visit for IAC 2019 in Washington, D.C.

The IAF Secretariat team has been closely interacting with the LOC of IAC 2019 through telecons as well as e-mail exchanges.

The calls for plenary proposals and abstracts submission were opened in November 2018. By the deadlines 26 plenary events and 18 highlight lecture proposals were received and more than 4300 abstracts were submitted, establishing a new record!

Registration for IAC 2019 was opened at the end of February 2019. A joint sponsorship strategy and related documents and agreements have been finalized between IAF and LOC.



Members of the IAF Secretariat travelled to Washington, D.C. from 16 to 18 January 2019, to conduct the traditional IAC 2019 Site Visit. Important requirements for the Congress, including establishing a baseline room allocation and a communication structure were successfully clarified, the congress venue and social events venues were inspected and important contacts were established guaranteeing a smooth interaction during the upcoming months. The IAF Secretariat delegation left the site visit with a very positive impression on the overall status of the work done by the US counterparts and the location itself.

11th Annual Conference on European Space Policy

The IAF President and IAF Secretariat attended the 11th Annual Conference on European Space Policy taking place in Brussels, Belgium. On 22 January 2019, the IAF and CNES hosted a joint lunch, with the participation of IAF and CNES President Le Gall, EU Commission Vice-President Šefčovič, Commissioner Bieńkowska and many other representatives of the EU Commission and various European Space Agencies.



IAC 2020 in Dubai Preliminary Contract Signature Ceremony

On Monday 11 February 2019, the International Astronautical Federation and the Mohammed Bin Rashid Space Centre (MBRSC) signed, on the occasion of the 2019 World Government Summit in Dubai, the preliminary contract for hosting the 71st International Astronautical Congress in Dubai, United Arab Emirates from 12 – 16 October 2020.



In addition, preparations for the 71st IAC in 2020 in Dubai have continued with an intensive exchange between the IAF and the MBRSC teams.

UNCOPUOS STSC

On 18 February 2019, the IAF took part in the 56th Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), held in Vienna. IAF President Jean-Yves Le Gall delivered the statement on behalf of the Federation.



Global Space Congress

On 19 and 20 March, the IAF President and IAF Executive Director attended the Global Space Congress 2019 in Abu Dhabi, UAE. In addition to participating to various panels, the President and Executive Director conducted several meetings for the preparation of the IAC 2020 in Dubai and coordination of joint activities in the months to come.



35th Space Symposium

The IAF was again present at the 35th Space Symposium from 8 to 11 April 2019 in Colorado Springs.



On Tuesday 9 April, the IAF hosted a networking breakfast that saw the participation of many IAF Vice Presidents and many key IAC 2019 stakeholders.

Satellite 2019

The IAF Secretariat was also present at the Satellite Show 2019 in Washington, D.C., from 6 to 9 May 2019, using the opportunity to coordinate IAC 2019 with AIAA.

SpaceOps Spring Meetings

From 13 to 17 May, the IAF Secretariat supported the entire week of the SpaceOps Spring Meetings in Cape Town, South Africa and worked on the preparation for the SpaceOps 2020 Conference call for abstracts and other preparations for the Congress.

62nd Session of UN COPUOS

On June 13, 2019, an IAF delegation was present at the 62nd session of UN COPUOS in Vienna. IAF VP for International Relations, Sergey Krikalev, delivered the report on behalf of the Federation.



The Federation used this opportunity to also conduct several meetings with partner organizations and members.

Paris Air Show - Le Bourget

The Federation also attended the Paris Air Show, held from 17 to 23 June 2019 in Paris in order to promote the IAF and its main upcoming events.

MAKS 2019

On 27 August 2019, the IAF President and Incoming President, the IAF Vice President for International Relations and Outreach and the IAF Executive Director, attended a GLEX 2020 promotional event in Moscow, Russian Federation, at the occasion of the MAKS 2019 Air Show, organized in cooperation with Roscosmos. During the event, which was chaired by Roscosmos' Director General Dmitry Rogozin, the Federation and the jointly organized GLEX 2020 conference were promoted.



SpaceOps Fall Meetings

From 11 to 14 November 2019, the Secretariat took part to the SpaceOps Fall Meeting in Munich, Germany. The goal was the definition of the programme in preparation of the SpaceOps 2020 Conference to be held in Cape Town, from 18 to 22 May 2020.

32nd Planetary Congress of the Association of Space Explorers

To further strengthen the IAF and ASE cooperation, the IAF Executive Director participated in the ASE Conference in Houston from 14 to 16 October 2019.

At this occasion IAF and ASE discussed the details of the joint ASE/IAF Astronauts session at the Global Networking Forum at the IAC 2019 Public Day.

GEO Week 2019 – Ministerial Summit

The IAF Subcommittee on The Global Earth Observation System of Systems participated in the planning for the GEO week in Canberra, Australia and an IAF delegation attended the meeting to deliver presentations and promote the Federation.



Dubai Air Show

The IAF and ROSCOSMOS attended the Dubai Airshow and hosted a very successful promotional event for the upcoming Global Space Exploration Conference, GLEX 2020.

The event was moderated by Sergey Saveliev (Vice President for Relations with International Organizations, International Astronautical Federation (IAF) and Deputy Director General, International Relations, ROSCOSMOS).



3rd International Moon Village Workshop & Symposium

The IAF attended the 3rd International Moon Village Workshop & Symposium in Tokyo on 6 December 2019. The IAF Executive Director gave a speech about “The International Astronautical Federation - *Connecting @ll Space People to Move Forward to the Moon*”



IAC 2020 Site Visit

On 15-17 December 2019 the IAF Secretariat went to Dubai, UAE to perform the traditional site visit and meet with the Host to lay the roadmap for the IAC 2020 preparation.





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 over 397 members from 68 countries including all leading 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



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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IAF Alliance Programme Partners:



Alliance Programme



IAF EVENTS 2020

Connecting @ll Space People



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