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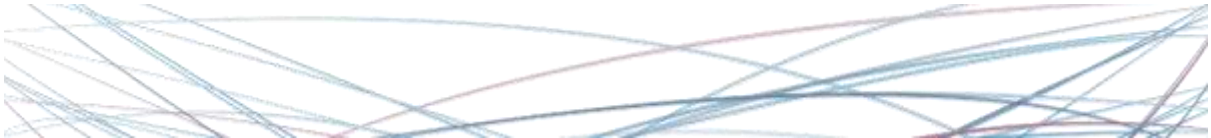
EXECUTIVE SUMMARY

After Budapest in 2016 and Paris in 2017, the 3rd edition of the European Space Generation Workshop (E-SGW) took place in Bucharest, Romania, on 9-10 March 2018. Over 100 delegates from 23 countries were joined by over 20 upstream and downstream space sector experts for SGAC's European flagship event. Hosted by the Bucharest Politechnica University, the two-day event provided delegates with the opportunity to not only listen to talks and panels, but also to benefit from peer to peer exchanges of knowledge, stories, adventures, personal histories, and their passion for space.

With space as the main bridging factor, students and young professionals from all across the space value-added chain came together to provide their contributions to a range of topics. The structure of the event, separated into morning panels, keynotes, and afternoon working sessions, also aimed to allow maximum interaction between the attendees to place the spotlight on their ideas. Experts and senior professionals joined the event to steer discussions, optimise conversation flows, and help enhance delegate outputs. The programme outline, presentations, and topics explored are available online at SGAC's website. The diverse range of topics echoed the complexity of the space domain, as well as the diversity of sponsors and partners joining the event. From space agencies such as the European Space Agency (ESA), the Centre National d'Études Spatiales (CNES), Agenzia Spaziale Italiana (ASI), and the Romanian Space Agency (ROSA) to companies such as GMV, ISpace, Piap Space, Inmarsat, and Space Apps—attending organisations took the opportunity to share, examine, and consider key questions faced by the regional space community on the workshop's main themes.

The Space and Cybersecurity Workshop, sponsored by ESA, invited participants to reflect on whether data should remain open source or limited in its availability and to identify possible technical solutions to counteract the shape and origin of threats to cybersecurity in space. The Space Exploration session addressed the current initiatives regarding spaceflight towards Mars, as well as the habitability of the planet. The Space Entrepreneurship session saw companies such as ISpace, PIAP Space, and PLD Space discuss the extension of the space market to commercial development and the challenges faced by new stakeholders in the sector when it comes to access to finance and scaling up their activities or products. However, the presence of more hardware in popular orbits adds to the problem of space sustainability and space debris mitigation, which were touched upon during group discussions. Investments in space provide significant returns in industry and commerce through the creation of spillover technology and their application to lucrative markets. Capacity building, disaster risk management, weather and climate monitoring, or water recycling—these are space applications that are often overlooked but key for human and economic development. Within the Space for Society Workshop Group, delegates exchanged on how to further support the take-up of satellite-based services by users, going beyond to reaching non-space communities, as well as how can space agencies frame their missions to ensure the public perception of their utility, and thus their long-term support.

The two-day event did not set out to cover and answer all the questions that arise with regards to the four chosen themes. Rather, it sought to open a process where these questions can be taken further by delegates and transformed into concrete actions. Whether they take the shape of reports, papers, briefs, policy recommendations, future Project Groups, or business ideas, delegates were strongly encouraged to build upon their work in Bucharest and continue to nurture the next generation's perspective on space matters.



SPONSORS AND PARTNERS

SGAC would like to thank all sponsors and partners for making the 2018 3rd European Space Generation Workshop possible.

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Faculty of Aerospace Engineering

Workshop Title Sponsors:

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PIAP SPACE

rosa romanian space agency

SPACE APPS

SGAC CHAIRS WELCOME NOTES

Dear E-SGW Delegate,

We were excited to welcome you to the 3rd European Space Generation Workshop and to Bucharest, Romania! If this was your first SGAC event, then welcome to the SGAC community. If you are an experienced SGAC member, welcome back and be sure to welcome new SGAC members to our global space community! You are all going to embark on a journey of not just learning about the perspectives of leading space experts, but also making connections with your peers, connections that will drive your professional life beyond this event. The Space Generation Workshop series started with the aim of providing an opportunity to our members to share regional perspectives on space activities, and we are pleased to see these efforts grow.

The E-SGW 2018 team has worked hard in the past few months to deliver a great program. Their goal was to enable you not only to share your views with industry leaders, but also to grow your professional network. We hope that you made use of the great speakers and moderators present at the event, along with the presence of colleagues with diverse backgrounds to fill in the gaps in your knowledge. We also wish you developed new ideas that can help scope the future of space activities in Europe and beyond. Of course, SGAC is not just about knowledge, but also about people. We hope that the social events organised as part of E-SGW 2018 and the interactive sessions helped plant the seed for strong lasting relationships and fostered future collaborations.

This event is the culmination of the hard work of an amazing team, a team that has been working tirelessly on this event for over six months. Please be sure to thank Alexandra, Corina, and their team for their hard work and dedication to making this event happen.

Ad Astra,
Ali Nasseri and **Alex Gibson**

EVENT MANAGERS WELCOME NOTES

Dear 3rd ESGW Delegates,

First and foremost, we are beyond grateful and proud to have received your support and we were delighted to meet you in Bucharest. To give you a bit of background, here's how everything started...

Once upon a time, almost a year ago, at the beginning of April, we decided to respond to the SGAC hosting bid for the 3rd European Space Generation Workshop. We had never met personally, we had no friends or acquaintances in common, we were living in different cities and countries, and had completely separate lives. By all karmic standards, we could have easily never met. But somehow in between our day jobs and personal lives, we were united in our belief that we wanted to bring this event to our country! With neither of us living in Romania, we turned to our networks to obtain the letters of support we needed for this project. We were absolutely thrilled to see so much encouragement coming our way! In May, our dream became a tangible reality when we received an email congratulating us for gaining the amazing opportunity to manage the organising team of the 3rd ESGW. In July, we were delighted to bring a great team on board and the rest is history... Team effort and dedication brought us here and we loved introducing you to Eastern Europe's 'Little Paris'!

The two-day event brought together representatives from leading institutions to help you navigate the challenges posed by the working session topics. The structure of the event allowed for maximum interaction between the attendees to place the spotlight on your ideas. This is a space where we are all equal.

The interventions of experts aimed only to steer discussions, to optimise the conversation, and enhance your outputs. It is your responsibility to question, debate, exchange, and go forward. And because good work cannot be done without a little bit of fun, the 3rd ESGW organising team has put together games and evening events meant to help you discover and learn from each other. We hope that you have enjoyed being part of this event as much as we enjoyed organising it, but most of all, we are hopeful that it will lead to new paths and opportunities in your academic or professional journeys.

With friendship,
Alexandra Jercaianu and **Corina Stiubei**

EVENT OVERVIEW

The 3rd European Space Generation Workshop (3rd E-SGW) is a two-day regional workshop for space enthusiasts. The workshop hosted up to 100 European delegates between 18 and 35 years old, focusing on university students (BSc, MSc, PhD students) and young professionals working in the European space sector. The objectives of the E-SGW are as follows:

- To strengthen the regional network of the students and young professionals in the European region and to build the bridge between today's and tomorrow's space sector leaders and professionals;
- To identify upcoming space sector challenges and opportunities, targeting to support future European and global policy initiatives to provide inputs from the next generation of the space professionals;
- To provide inspiring workshops, panels, and presentations to encourage youth contribution to space on topics from entrepreneurship to space explorations, sustainability, emerging new actors or cybersecurity.

This year, E-SGW working groups addressed the following topics: Space and Cybersecurity (supported by ESA), Space Exploration, Emerging Space and Space for Society. Working groups served as an integral part of the workshop with the overall aim of producing tangible deliverables resulting from robust discussions by the participants.

Attendees were divided into four groups of their choosing, where they discussed selected issues or themes that are relevant to the role of space science in society. Current leaders and subject matter experts in the international space sector joined in to share their perspectives and assist with the discussions. Following the panels and workshop exchanges, delegates presented their recommendations with their peers on the final day of the conference.

Furthermore, reports from the projects will be presented at conferences and included in the SGAC annual report submitted to the United Nations Committee on the Peaceful Uses of Outer Space (UN COPUOS). Participants were also encouraged to use and turn the outputs into conference papers, research, business ideas and so on.

EVENT HIGHLIGHTS

CyberSpace & Security Panel

Panelists: Christina Giannopapa (ESA), Patrick O'Keeffe (NATO), Bleddyn E. Bowen (University of Leicester)

Moderator: Caroline Thro, ESA
The space sector is unique in the field of cybersecurity. It is an industry where civil, commercial, and military applications seamlessly co-exist, creating a haphazard situation for cybersecurity experts and telecommunication engineers. This panel saw experts from civil, military, and academic backgrounds take the stage to share their perspectives on the nature of space and cybersecurity: what the priorities of governments and international institutions should be, whether data should remain open source or limited in its availability, possible technical solutions to the challenges posed above, and the shape and origin of threats to cybersecurity in space.

Space Entrepreneurship Q&A

Panelists: Kyle Acerino (ispace), Jarosław Jaworski (PIAP Space), Francisco Lacarte (PLD Space)
Moderator: Matteo Emanuelli, SGAC
The emergence of private investment in space activities has opened up the space market to commercial development and private-public partnerships in a way we have never seen before. New technologies and manufacturing processes are disrupting the space access and satellite markets. We are increasingly seeing companies propose and implement networks of tens to thousands of small satellites—such a massive amount of data will easily feed the Industry 4.0 and IoT age, but also the presence of more hardware in popular orbits adds to the problem of space sustainability and space debris mitigation. New use means new challenges, and the public and private sector must be ready to adapt and meet

them. This panels showcased representatives from three emerging companies looking to disrupt how we think and see space activities.

Space Exploration Panel

Panelists: Marino Crisconio (ASI), Jakub Knir (Foster and Partners), Christian Ohlendorff Knudsen (Mars One Candidate), Franco Fenoglio (Thales Alenia Space), Andrea Pellacani (GMV)
Moderator: Akash Trivedi
Speakers representing space agencies, industry and startups gathered together to discuss the current initiatives regarding spaceflight towards the Moon and Mars, as well as the complex challenges of sending tons of payloads such a long distance away, whilst ensuring the safety of the crew and providing comfort, food, and services. Questions regarding the usability, feasibility, and funding of such missions were addressed from different perspectives.

Cultural Night

The Cultural Night brought together E-SGW delegates from 23 countries to share some of their culture with each other. The event took place on March 9th at Mezanin Space and welcomed both delegates and speakers to a night of informal networking. During this evening, each attending country representative contributed to a show of around five minutes on their country's traditions and customs. Music, dance, quiz, presentations... a crash course on deciphering the Italian sign language and even stand-up sketches were included by delegates in their programmes.

Closing Dinner

The 3rd E-SGW closing dinner took place in a palace in the heart of Bucharest. Ghica Palace is a landmark of history and heritage, a spectacular premium location for stylish banquets and receptions. Delegates enjoyed dinner while tasting the époque elegance of 1880s. You can hardly find a more glamorous way to end the 3rd E-SGW than a renaissance palace.

SPEAKERS AND SUBJECT MATTERS

Participants to the 3rd European Space Generation Workshop had the opportunity to engage with experts from across the space community, ranging from high-ranking agency officials to experienced industry professionals.

Keynote & Invited Speakers

Marius-Ioan Piso, *Director, Romanian Space Agency*

President of the Romanian Space Agency (ROSA) since 2004 and also Executive Director of the same organisation since 2005, Marius-Ioan Piso, PhD in physics and Senior Scientist 1st degree, coordinates the Agency's development following three strategic directions: the implementation of the Romanian space strategy planning and coordination, representing Romania nationally and internationally and the constant development of partnerships, collaborations and bi- and multilateral relationships, and last but not least, the Agency's involvement in national and international research and development programmes in space, aeronautics and security domains. His name is linked to the establishment of the Romanian Space Agency in 1991 and the achievement of the organisation's independency four years later, to the foundation of the Institute of Space Science, and also to the inception of Romania's and European Space Agency (ESA) cooperation. The constant concern regarding space research and technology development in Romania and the results obtained over time by the scientific and technological community, often under his supervision or guidance, resulted in the country's accession to the European Space Agency in January 2011.

Kai-Uwe Schrogl, *Chief Strategy Officer, European Space Agency*

Prof. Dr. Kai-Uwe Schrogl is the Head of the Strategy Department in the Director General's Cabinet of the European Space Agency (ESA, Headquarters in Paris, France). From 2007 to 2011 he was the Director of the European Space Policy Institute (ESPI) in Vienna, Austria, the leading European think tank for space policy. Prior to this, he was the Head of the Corporate Development and External Relations Department in the German Aerospace Center (DLR) in Cologne, Germany. Currently he is the chairman of the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space, the highest global body for space law making, comprising 73 Member States. He also served as the chairman of other bodies as the ESA International Relations Committee. He presented, respectively testified, at hearings of the European Parliament and the US House of Representatives. Kai-Uwe Schrogl is Vice President of the International Institute of Space Law, Member of the International Academy of Astronautics (recently chairing its Commission on policy, economics and regulations) and the Russian Academy for Cosmonautics as well as Corresponding Member of the French Air and Space Academy.

Dumitru Prunariu, *Romanian Astronaut, Romanian Space Agency*

Dumitru Prunariu, Romanian pilot and cosmonaut, was the first Romanian citizen in space. He earned a degree in aerospace engineering from the Polytechnic University in Bucharest in 1976, and a PhD in spaceflight dynamics in 1999 from the National Defence College. In 1978 he became a senior lieutenant in the air force and was selected for spaceflight training as part of the Intercosmos programme. Prunariu finished his training at the top of his class and was chosen to accompany Soviet cosmonaut Leonid Popov for a joint spaceflight. Prunariu and Popov launched on May 14, 1981, aboard Soyuz 40 and docked with the space station Salyut 6. The crew spent nearly eight days in space conducting experiments in the fields of biology, medicine, and physics.
Prunariu returned to the Romanian air force as the chief inspector for aerospace activities and taught courses in aerospace engineering at the Polytechnic University. He held positions with the Romanian Space Agency (ASR), the General Staff of Aviation and Air Defence, and was the Romanian

ambassador to Russia and chair of the Scientific and Technical Subcommittee of the United Nations Committee on Peaceful Exploration of Outer Space (2004 - 2006) and Chairman of UN COPUOS (2010-2012). Between 2006 and 2008 Prunariu accomplished the duties of the Director of the Romanian Office for Science and Technology to the European Commission (ROST) in Brussels. In 2012 Prunariu was appointed as one of the 15 experts of the Group of Governmental Experts on outer space transparency and confidence-building measures, established by the UN General Assembly Resolution 65/68. In 2014 Prunariu was elected for a three-year term as the vice-chairman of the International Relations Committee of ESA, and was also a member of the task force elaborating a report on Space Security for Europe in the framework of the European Institute for Security Studies (EUISS), issued in 2016. Currently, Prunariu is working for the Romanian Space Agency as an expert within the Romanian Association for Space Technology and Industry – ROMSPACE.

Christina Giannopapa, *Head of the Political Affairs Office, European Space Agency*

Dr. Christina Giannopapa is the Head of the Political Affairs office in the Strategy Department of the European Space Agency. She is responsible for offering political support and advice to the Director General, as well as implementing the Agency's space security and safety policy. Prior to joining ESA, she has worked as a consultant to high-tech industries in research and technology development. She held positions in academia in Eindhoven University of Technology, the Netherlands and in the University of London, UK. She has received 14 academic scholarships and awards and has 40 publications in peer-reviewed journals and conferences. She holds a PhD in Engineering and Applied Mathematics; an MEng in Manufacturing Systems Engineering and Mechatronics; and an MBA in International Management from the University of London, UK. Additionally, she holds an assistant professor position in multiphysics at Eindhoven University of Technology. She is the chair of the Fluid Structure Interaction (FSI) Committee of the American Society of Mechanical Engineers (ASME) and is the secretary of the Committee for Liaison with International Organisations and Developing Nations (CLIODN) of the International Astronautical Federation (IAF).

Virgiliu Pop, *Manager, ESERO*

Virgiliu is a Romanian space lawyer and author, who currently works for the Romanian Space Agency and is publicly active in promoting space efforts in Romania. Since 2014, he has been the Manager of the European Space Education Resource office, which is a collaboration between ESA and its national partners. Virgiliu is a motivated and enthusiastic supporter of human space exploration, and an expert in the areas of space law, space policy, and space history.

Ioana Selaru, *Technical Recruiter, HESpace*
Ioana is a technical recruiter at HE Space since and has a wealth of knowledge about the space and IT&C industries. She enjoys working with groups and individuals to understand their behaviours and the way professional environments can shape their personalities.

Patrick O'Keeffe, *NATO Legal Advisor, Centre of Excellence for Operations in Confined and Shallow Waters/ Institute for Security Policy at Kiel University (ISPK)*

Patrick O'Keeffe is a German Navy Officer serving as NATO Legal Advisor at the Centre of Excellence for Operations in Confined and Shallow Waters (COE CSW). An aerospace engineer specialised in astrodynamics and satellite operations, and a former military aviator, Patrick O'Keeffe's works in a multidisciplinary environment focusing on the impact of disruptive technologies and legal challenges on the strategic transformation of NATO. In addition, as the managing director of AMC Solutions, Patrick O'Keeffe assists NGOs, GOs, IGOs, and companies on aerospace, maritime, and cyber strategies and policies.

Bleddyn E. Bowen, *Lecturer in International Relations, University of Leicester*

Dr. Bleddyn is a lecturer in international relations in the School of Politics and International Relations at the University of Leicester, where he teaches the module 'Politics and War in Outer Space'. Before January 2018, he was a Lecturer in Defence Studies at the Defence Studies Department, King's College London, which is embedded at the Joint Services Command and Staff College, Shrivenham. Prior to this, he was a Teaching Fellow at the Department of International Politics, Aberystwyth University. His research interests focus on *spacepower* theory, space policy and security, modern warfare, and strategic theory/military history. He is the founder of the Astropolitics Collective, a loose affiliation of scholars and professionals who research and work on the politics of outer space.

Caroline Thro, *Contracts Officer for the Mission Operations & Ground Segment Engineering Procurement Service, European Space Agency*

Ms Caroline Thro has been working in the Launchers and HQ Procurement Division in ESA HQ Daumesnil for the last three years, before recently joining as a Contracts Officer the Mission Operations & Ground Segment Engineering Procurement Service at the European Space Agency in Darmstadt, Germany - ESOC. She graduated in Space Law in 2014 from the University Paris-Sud. The same year she won with her team the Regional Rounds of the Manfred Lachs Moot Court Competition and became semi-finalist in the World Finals of this same Competition.
Caroline has been actively involved in SGAC activities since 2016 (the most notable as Event Manager for the 2nd European Space Generation Workshop which took place at ESA HQ in March 2017) after having already attended several SGAC events as a Delegate. Since January 2018 she is the Regional Events Coordinator of SGAC.

Kyle Acerino, *Managing Director, iSpace Europe*

Kyle Acierno is an international expert in commercial space and a specialist in lunar exploration. Over the past decade, he has developed broad knowledge extending into space science, engineering, law, policy, finance, and business development. As an international speaker, Kyle has presented at over 100 conferences worldwide. He is a member of numerous working groups, both commercial and technical, and regularly contributes to legal debates surrounding space resources.
Currently, Kyle works as the Managing Director of ispace Europe. ispace is a lunar exploration and transportation company with its headquarters in Japan and regional offices in Luxembourg and at NASA AMES in California. ispace manages the front-running competitor in the Google Lunar XPrize, Team Hakuto.

Andrea Pellacani, *AIM Project Manager, GMV*

Andrea joined GMV in Madrid in 2012, after completing a Master of Science in aerospace engineering at Bologna University, with cum laude. He started working as AOCS/GNC Engineer and he has involved in several projects since then, such as Google Lunar XPrize, Lunar Lander, and Debris Removal Systems. Since 2015 he is programme manager for AIM, Asteroid Impact Mission.

Matteo Emanuelli, *SGAC*

Matteo Emanuelli works as Systems Engineer at GOMSPACE, a leading nanosatellite company located in Denmark. He is the technical manager on a constellation of spacecraft for tracking aircraft and ships. Previously, Matteo worked with nanosatellites in France and in the Netherlands for HE Space. Matteo has been involved in SGAC since 2011 and in various roles, first as National Point of Contact for Italy, subsequently as Co-Lead of the Space Safety and Sustainability Project Group, and now in his current position as Regional Coordinator for the European Region for almost 4 years.

Jarosław Jaworski, *Head of Robotics, PIAP Space*

Jarosław is a Head of Robotics Section at PIAP Space, responsible for business and technology development for On-Orbit Satellite Servicing and Planetary Robotics. The goal of PIAP Space is to provide a set of products for planetary missions, orbital services and MGSE design. Jaroslaw previously worked as a systems engineer, and has Master's qualifications in both Aerospace Engineering and Finance and Accounting. Jaroslaw is an alumni of International Space University Space Summer Programme 2014 (Canada) and volunteered as a Teaching Associate in 2016 (Israel). He is a former SGAC NPoC for Poland.

Francisco Garcia Lacarte, *Aerospace Engineer, PLD Space*

Francisco Garcia is a Spanish aerospace engineer that currently is working at PLD Space. After working at Airbus Space (Madrid) and at the European Space Agency (ESTEC, Netherlands) Francisco decided to follow his entrepreneurship side and joined the rocket startup company PLD Space in 2016, which aims to develop the first European reusable launcher. Francisco is also the NPoC of Spain for SGAC since 2016.

Mansoor Shar, *Asset & Investment Analyst, Inmarsat*

Mansoor is an analytical and strategic thinker with broad experience and passion for space, technology, investing, and startups. His background includes international experience working in complex business environments for Fortune 100, FTSE-100, mid-size and emerging businesses in the US and Europe. He has a core understanding of business needs and challenges, leveraging technical background, business knowledge and entrepreneurial spirit to drive results. He currently holds the position of Asset & Investment Analyst at Inmarsat and supports the SGAC as both a Web Editor and Finance and Strategy officer.

Maria-Gabriella Sarah, *Partnerships Analysis and Dev Officer, European Space Agency*

Maria-Gabriella is an electrical engineer (graduated from the French Grande Ecole Supelec) and joined ESA in 2002. She had several roles starting in the Science Directorate as an operations engineer and moved after 6 years to a Corporate role, in DG's services, putting in place the Risk Management framework for the Agency. She is now responsible for building new partnerships with non-space businesses and for the relationships with some of ESA member states including Romania.

Ildiko Tulbure, *Associate Professor, University 1 Decembrie 1918*
Ildiko is an associate professor both in the Department of Sciences of the University 1 Decembrie 1918, Alba Iulia, Romania and in the Institute for Applied Mechanics of the Classical University of Technology in Germany. She is an expert in recognising and helping to develop patterns of behaviour and action to assure the sustainability of our society. Her skills and expertise range from Environmental Impact Assessment to Numerical Modelling and Knowledge Management.
In 2017, her scientific paper, 'Space Activities Incentive for Global Sustainability', co-written with Dumitru Prunariu, the only Romanian astronaut, has received a prize in an international conference.

Akash Trivedi, *SGAC*

Akash Trivedy is currently doing a DPhil in Engineering Science at Oxford University, where he is also a tutor. He is the SGAC National Point of contact for the UK since 2014. Akash was involved in an Analogue Astronaut mission (MDRS) with Crew 184 at the Mars Society's Mars Desert Research Station in the Utah desert in December 2017. Akash had the roles of Science Officer and EVA Officer. He coordinated the major scientific projects and managed all extravehicular activities for the six-person crew relating to the geological research project. He also created and managed the online presence of the crew as Outreach Officer.

Jakub Knir, *CFD Specialist, Foster and Partners*

Jakub Knir is a Computational Fluid Dynamics (CFD) specialist in Foster + Partners, in London. Foster + Partners is a global studio for sustainable architecture, urbanism and design. Since 2012, they have expanded their industrial research from the Earth to the Moon as they were selected to be part of a consortium set up by the European Space Agency to explore the possibilities of 3D printing to construct lunar habitations. Addressing the challenges of transporting materials to the moon, the study investigated the use of lunar soil, known as regolith, as building matter. On 2015, they worked on a NASA-backed competition for a 3d-printed modular habitat on Mars. The design for the Mars Habitat outlines plans for a settlement constructed by an array of pre-programmed, semi-autonomous robots prior to the eventual arrival of the astronauts.

Marino Crisconio, *Program Manager, ASI*

Marino Crisconio works in the Human Flight and Microgravity Dep. of the Italian Space Agency. He graduated in Aeronautical Engineering at the University Federico II and, and later, he received his PhD in Aerospace Engineering with a thesis on the Study of a New Remote Control System for Microgravity Experimentation on Board the International Space Station. After spending a few years in a centre for research on microgravity in Naples (the MARS Centre), he arrived in ASI in 1998.
In his early years in ASI, he worked in the field of small satellites, being involved in the projects MITA, PRIMA, HypSEO and AGILE (still on orbit). Then he started working on the International Space Station. He has been (or still is) responsible for 11 experiments that flew (or are going to fly) on the ISS in the frame of its Italian use.
He is delegate to some ISS Boards, advisor to the ESA Program Board Human Spaceflight, Microgravity and Exploration, and delegate to the International Space Exploration Coordination Group.

Franco Fenoglio, *Head of Human Spaceflight & Transportation Unit, Thales Alenia Space*

Franco Fenoglio is currently Head of the Human Spaceflight & Transportation Programs Unit in Thales Alenia Space - Italia. He has more than 25 years of engineering and management experience in space systems, including life support subsystems, system engineering and management of large and complex pressurised modules for the International Space Station, transportation and re-entry vehicles, space exploration scenarios and studies. Franco is also very familiar with the international context of the space industry, both European and American, and he has collaborated with some major space international entities in France, Germany and with NASA in the USA.

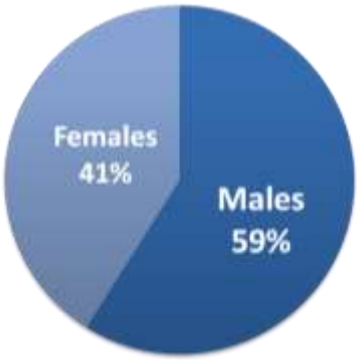
Christian Ohlendorff Knudsen, *Systems Engineer and Mars One Candidate*

Christian Ohlendorff Knudsen is the only Dane left within the 100 candidates from around the world, wanting to participate in the Mars One mission. Mars One is a Dutch non-profit, aiming to construct a human settlement on Mars. After entering the selection process, and meeting some of the other candidates, Christian rejects the common prejudice that the people wanting to leave Earth are depressed souls, just looking for a spectacular way to end their lives. On the contrary, he believes that it is all about transcending one's own emotional life for a greater good. Christian himself wants to give something back to the society which has given him so much, ultimately helping humanity to move forward.

EVENT STATISTICS

The event received 140 applications, and 100 delegates were invited to attend.

Gender balance:



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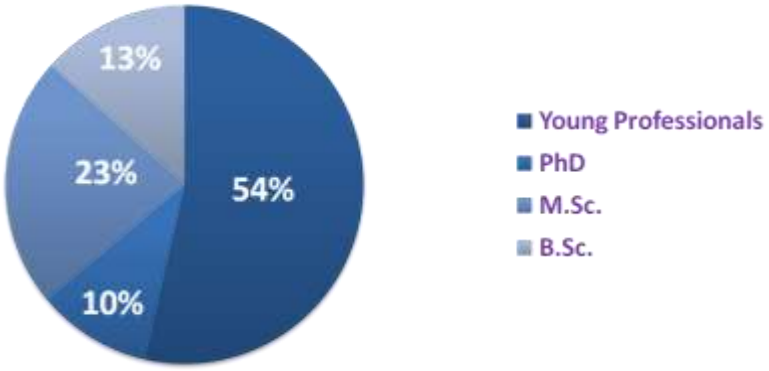

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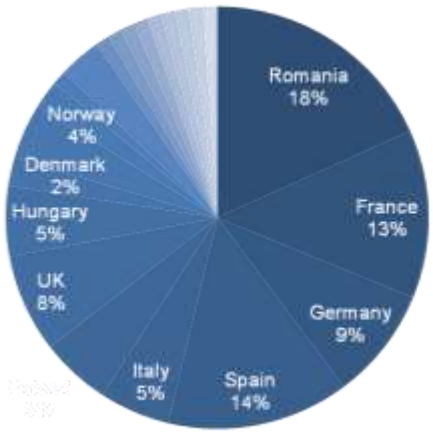


PROGRAMME

Day 1 - 9th of March 2018

9:15-9:30 Welcome
Alexandra Jercaianu, Event Manager and **Corina Stiubei**, Deputy Event Manager

9:30-11:00 Keynote Addresses
9:30-9:45 – Marius-loan Piso, Director of Romanian Space Agency
9:45-10:00 – Christina Giannopapa, Head of the Political Affairs Office, European Space Agency
10:00-10:15 – Victor Negrescu, Romanian Minister for European Affairs
10:15-10:30 – Mihnea Costoiu, Provost University Politehnica of Bucharest
10:30-11.00 – Dumitru Prunariu, Romanian Cosmonaut, Romanian Space Agency

11:00-11:30 Coffee Break

11:30-12:30 Space & Cybersecurity Panel
Moderator: Caroline Thro, ESA
Panellists:
Christina Giannopapa, Head of the Political Affairs Office at the European Space Agency
Patrick O'Keeffe, NATO Legal Advisor at the Centre of Excellence for Operations in Confined and Shallow Waters (COE CSW)
Bleddyn E. Bowen, Lecturer in International Relations at the University of Leicester

12:30-13:00 Stories of Space Companies
Speakers:
Kyle Acerino, Managing Director at ispace Europe S.A.
Jarosław Jaworski, Head of Robotics at PIAP Space

13:00-13:30 Space Entrepreneurship Q&A

Moderator: **Matteo Emanuelli,** SGAC

Entrepreneurs:

Kyle Acerino, Managing Director at ispace Europe S.A.

Jarosław Jaworski, Head of Robotics at PIAP Space

Francisco Garcia Lacarte, Aerospace Engineer at PLD Space

13:30-14:30 Lunch Break

14:30-16:15 Working Groups

Space & Cybersecurity	Space for Society	Space Exploration	Emerging Space
Sponsor: ESA **Patrick O'Keeffe,** NATO Dr**. Bleddyn E. Bowen,** University of Leicester **Christina Giannopapa,** ESA Moderator**:** Harry Jervis	**Ildiko Tulbure,** 1 Decembrie 1918 University **Maria-Gabriella Sarah,** ESA Moderator: Katherine Pangalos	**Marino Crisconio,** ASI **Jakub Knir,** Foster and Partners **Christian Ohlendorff Knudsen,** Mars One Candidate Moderator: Laia Ramio	**Jarosław Jaworski,** PIAP Space **Mansoor Shar,** Inmarsat Moderator: Eloise Matheson

16:15-16:45 Coffee Break

16:45-18:00 Working Groups

Space & Cybersecurity	Space for Society	Space Exploration	Emerging Space
Sponsor: ESA **Patrick O'Keeffe,** NATO Dr**. Bleddyn E. Bowen,** University of Leicester **Christina Giannopapa,** ESA Moderator**:** Harry Jervis	**Ildiko Tulbure,** 1 Decembrie 1918 University **Maria-Gabriella Sarah,** ESA Moderator: Katherine Pangalos	**Marino Crisconio,** ASI **Jakub Knir,** Foster and Partners **Christian Ohlendorff Knudsen,** Mars One Candidate Moderator: Laia Ramio	**Jarosław Jaworski,** PIAP Space **Mansoor Shar,** Inmarsat Moderator: Eloise Matheson

18:00-18:15 First Day Round Up

19:30-23:00 Cultural Night

Day 2 - 10th of March 2018

9:20-10:15 2nd Day Introduction

9:20-9:30 – Alexandra Jercaianu & Corina Stiubei, Event Managers
9:30-9:45 – Virgiliu Pop, Space Lawyer and author, ESERO
9:45-10:00 – Ioana Selaru, Technical Recruiter at HE Space

10:15-10:45 Lecture: Space for Society
Kai-Uwe Schrogl, Chief Strategy Officer, European Space Agency

10:45-11:15 Lecture: Autonomy - Key enabling technologies for future space exploration
Andrea Pellacani, AIM Project Manager, Space Systems and Robotics Business Unit GMV

11:15-11:45 Coffee Break

11:45-13:00 Space Exploration Panel

Moderator: Akash Trivedi, SGAC
Panellists:
Marino Crisconio, Human Spaceflight Department, Italian Space Agency (ASI)
Franco Fenoglio, Head of Human Spaceflight and Transportation Programs, Thales Alenia Space Italy
Jakub Knir, CFD Specialist in Foster and Partners
Christian Ohlendorff Knudsen, Mars One Candidate
Andrea Pellacani, AIM Project Manager in GMV

13:00-14:00 Lunch Break

14:00-16:00 Working Groups

Space & Cybersecurity	Space for Society	Space Exploration	Emerging Space
Sponsor: ESA **Patrick O'Keeffe,** NATO Dr**. Bleddyn E. Bowen,** University of Leicester **Christina Giannopapa,** ESA Moderator**:** Harry Jervis	**Ildiko Tulbure,** 1 Decembrie 1918 University **Maria-Gabriella Sarah,** ESA Moderator : Katherine Pangalos	**Marino Crisconio,** ASI **Jakub Knir,** Foster and Partners **Christian Ohlendorff Knudsen,** Mars One Candidate Moderator: Laia Ramio	**Jarosław Jaworski,** PIAP Space **Mansoor Shar,** Inmarsat Moderator: Eloise Matheson

16:00-16:30 Coffee Break

16:30-18:00 Working Groups Presentations

18:00-18:15 Closing Remarks

20:00-23:00 Closing Gala Dinner

3rd E-SGW ORGANISING TEAM

A team of dedicated volunteers makes up the organising team of the 3rd European Space Generation Workshop. These passionate students and young professionals have worked tirelessly to ensure the 3rd E-SGW delegates enjoy the best possible experiences and opportunities while in attendance. On behalf of the SGAC Executive Office, we thank them for their time and dedication.

Alexandra Jercaianu (Romania)

Event Manager

An International Security Master's degree graduate from SciencesPo Paris, Alexandra joined the space sector in 2015 when she took up the position of Project Administration at Eurisy, an association of space agencies tasked with raising awareness of the benefits of satellite-based services for society. In her current position, Alexandra manages Eurisy external communications and events aiming to stakeholders across the space value-added chain together with public authorities and non-space SMEs to exchange know-how and good practices on operational and potential uses of satellite technology in various sectors. An avid traveller, she enjoys discovering new cultures and collecting stories from the people she meets.

Corina Stiubei (Romania)

Deputy Event Manager

In August 2013 Corina was appointed National Point of Contact for Romania, a position which she has been occupying ever since. In the context of this extra-curricular activity, Corina was elected team leader two years in a row for the Find an Asteroid International Search Campaign, coordinating a team of 5 including herself, with teammates from Vietnam, Brazil, Russia and Ukraine. In April 2014, Corina joined the European Space Expo team as local support and booking coordinator for schools in Craiova and Dolj County (Romania). Prior to obtaining a Master of Science degree in Aviation Management from FH JOANNEUM, University of Applied Sciences, Department of Aviation, in Graz, Austria, Corina has graduated from University Politehnica Bucharest, Faculty of Aerospace Engineering with a Bachelor of Engineering degree in Air Navigation. As of March 2017, Corina went back to her first passion, aviation, by taking the Manager for Safety Data Analysis and Performance Review position within the European Business Aviation Association

Programme Team

Harry Jervis (France)

Harry Jervis is currently a trainee in the Strategy Department of the European Space Agency, Paris. Prior to this, he graduated with a BA Political Economy at King's College London where he was a member of the KCL European Society committee. There, he helped organise the annual European Week conference. He also played a part in setting up The European Society UK organisation, which aims to promote European culture and values among young people. With a passion for Space and Europe, volunteering for the 3rd Space Generation Workshop is Harry's first true engagement with SGAC.

Eloise Matheson (Australia)

Eloise Matheson is a robotics engineer currently pursuing her PhD in Medical Robotics at Imperial College, London, focusing on the development and implementation of a surgical device aimed for neurosurgical operations. Previously she worked in the Telerobotics and Haptics Laboratory at ESTEC, ESA for 2.5 years and has interests in space and medical robotics, teleoperation and haptic shared control.

Laia Ramio Tomas (Spain)

Laia Ramio Tomas is currently working as an AOCS engineer for Earth Observation missions at Thales Alenia Space, in France. Before that, she started her career as an Instrument Systems Engineer at Airbus Defence and Space in the UK, where she took part in the Graduate Development Programme. She holds an Aerospace engineering degree from the Polytechnic University of Catalonia (UPC) and an MSc in Astronautics and Space Engineering from Cranfield University, in the UK. Laia is a STEM Ambassador and has always enjoyed being involved in outreach activities. She first met the SGAC in 2014 at the IAC in Toronto, where she was presenting her Master's Thesis.

Delegate Team

Laura Manoliu (Romania)

Laura Manoliu is currently pursuing her Master's Degree at University of Stuttgart, Germany, with thesis applied in future satellite telecommunication systems. Her research interest is focused on Radio Frequency engineering, circuit design, and antennas. She gained practical experience by working as a student research assistant at Institute of Robust Power Semiconductor Systems (ILH) for 2 satellite networks projects in cooperation with DLR and by attending numerous ESA programmes. During her bachelor, Laura participated together with her colleagues, in the REXUS 16 sounding rocket programme (Low Gravity project). For this project, they obtained the Best Team Project Award at International Astronautical Congress in 2013 in Beijing, China.

Antonio Carlo (Italy)

Antonio Carlo is currently a trainee in the Strategy Department of the European Space Agency. He graduated with honours from La Sapienza – University of Rome with a Master's Degree in International Relations. He is studying once again at La Sapienza for his second Masters in Political Science. On top of his second masters, he is also currently studying at PISAI Pontifical Institute for Arabic and Islamic Studies where he is strengthening his understanding on Arabic culture and language. In 2016, Antonio participated in the 25th ECSL Summer Course on Space Law and Policy in Warsaw. Further, in 2017 he participated in the Manfred Lachs Space Law Moot Court Competition held at the University of Helsinki in Finland. As team leader, he was responsible for organising and coordinating his university's participation.

Communication Team

Istvan Arnocz (Hungary)

Istvan Arnocz is a Transport Engineer with a Master's degree in Autonomous Train Control Systems from the Technical University Budapest (Budapest, Hungary). He has more than 4 years of work experience from Siemens AG where he managed outdoor and indoor installations and commissions of the Metro line 2 and 4 in Budapest. In parallel to engineering, Istvan also started to learn marketing (digital and print) and has worked in this sector as well. He joined SGAC in 2015 and became the NPoC for Hungary in early 2016. He also worked on the Communications team for the first E-SGW that took place in Budapest in February 2016. Istvan founded a Space related startup called Space Apps which focuses on space data, GIS, IoT, and ANNs.

Davide Petrillo (Italy)

Davide Petrillo is currently working as a Business & Integration Consultant for Accenture, global management consulting company that provides strategy, consulting, digital, technology and operations services. Davide has a M.Sc. in Aerospace Engineering from the University of Padova, Italy. Previously, he was the Team Leader of FELDs Experiment selected by the European Space Agency (ESA) for the Drop Your Thesis! 2014 programme. FELDs tested a tethered electromagnetic soft docking technology in microgravity conditions at the Drop Tower of the Centre of Applied Space Technology and Microgravity (ZARM) in Bremen, Germany. In 2015, he won the Hans Von Muldau Team Award for the best team project that took place in Jerusalem at the 66th International Astronautical Congress (IAC).

Alessandro Sutto (Italy)

Alessandro Sutto, graduated with a bachelor's degree in Architecture, and is pursuing his master's degree in Architecture at IUAV University of Venice, Italy. During his academic career, Alessandro has collaborated as part of W.A.VE. an International Architecture workshop whose main objective is to foster, network and collaborate between Architecture and Design professionals from all over the World. Alongside his architectural projects, he also carries forward a passion for graphics and this led him to attend the realisation of several works in the field of graphic design. Alessandro has devised and realised the graphics for the 3rd European Space Generation Workshop, in its various formats.

Logistics Team

Ludovica DiLullo (Italy)

Ludovica Di Lullo is a PhD in International Law at Sapienza University of Rome, and she's focusing her research on International Space Law. She graduated with honours in Political Science and International Relations and during her studies, she attended the 23rd European Centre for Space Law (ECSL) Summer Course on Space Law and Policy held in Geneva, and then she served as tutor at the 25th ECSL Summer Course in 2016 in Warsaw. She worked for six months at Eurisy, an NGO based in Paris operating in the field of space benefits for society.

Roman Mykhalchyshyn (Ukraine)

Roman is an engineer at Yuzhnoye SDO in Ukraine since 2011. His specialization is designing and testing of launch vehicle propulsion systems. He is a PhD student in launch vehicle performance improvement; the scope of the investigation is improvement of launch vehicle pressurisation and propellant systems. Roman is an author of seven science and research articles, presented one of my works at International Astronautical Congress 2016 and received glowing references. He is one of the three winners of the SGAC-IAASS Space Safety Competition. Roman is a member of the space sector Young Professional Council as a head of science and research department. In free time, he organises science events with space themes, takes part in the conferences (as author and as volunteer) in Ukraine.

Larisa Popa (Romania)

Larisa Popa is currently pursuing her Bachelor's Degree at Polytechnic University of Bucharest, Faculty of Electronics, Telecommunications and IT. She is determined to develop a career in electronics applied in the space field of expertise. Being part of the 3rd European Space Generation Workshops' team is her first involvement in spatial environment. She is aiming to improve her passion for spatial technology and become a successful engineer in this area.

WORKING GROUP RECOMMENDATIONS

One of the core activities during the third European Space Generation Workshop were the Working Group sessions. Guided by experienced Subject Matter Experts, the groups discussed pertinent space topics in a European context.

Delegates collaborated with subject matter experts to address predefined questions in four highly relevant areas:

- Cyberspace and Security
- Space for Society
- Space Exploration
- Emerging Space

The preliminary conclusions and recommendations of each group were presented to the rest of the delegates and attending experts at the end of the workshop.

CYBERSPACE AND SECURITY

Figure 1: Image from [1]

Moderator: Harry Jervis

Subject Matter Experts: Christina Giannopapa (ESA), Patrick O'Keeffe (NATO/ISPK), Bleddyn E. Bowen (University of Leicester)

Reporters: Hannah Lindberg, Francesco Murdaca, Pilar Guerrero Gallarin

Delegates: Aase Thea Dethlefsen, Daniel Benyei, Silvia Batorii, Vincent Lee, Victoria Schebek, Mihnea-Nicolae Tanase, Vera Leister, George James, Monika Johanna Pardo, Mari Eldholm, James Murdza, Daria Stepanova, Josep Gomez Marti, Alexandru Rusu Casandra, David Portilla Abellan, Lucie Cordier, Costel Cherciu, Fares Elsherbiniy, Rania Toukebri, Casiana Marcu, Gina Petrovici, Ionut Cimpian

Sponsor

Introduction

Spacecrafts and space-borne technologies have a crucial role in sustaining modern society. Financial markets, transport networks, emergency services, national defence systems, and more would collapse if at any point all the space-based capabilities were disabled. Thus, satellite data communication reliability and spacecraft control security measures have become a crucial topic for space private services providers, space agencies, governments and spacecraft manufacturers worldwide.

Satellite information protection measures need to be submitted to a constant renewing and redefining process to maintain their robustness in a constantly changing infrastructure, one where threats and cyber-attacks can be of different natures and driven by diverse purposes.
Data exchange policies must be simultaneously compatible with space technology and market evolution trends. Cybersecurity must ensure the harmonious co-existence of highly confidential military programs and collaborative multi-entity projects in which satellites are designed with open source software and open access data.
This workshop was targeted at addressing several questions related to space and cybersecurity and the discussions aimed to define new guidelines for cybersecurity enhancement in satellite programs. Following the analysis of space program vulnerabilities, three main fields were identified as being crucial for the proactive prevention of cyber-attacks: social awareness campaigns, technical firewalls and legal actions. This report seeks to summarise the discussions held and provide valuable recommendations to increase international standardisation and resilience on space cybersecurity actions.

Objectives

Our key objective was to involve delegates from different nations and disciplines to give their inputs and discuss with each other around the following topics:

- The effects of the adoption of new technologies in space telecommunications
- The criticalities and liabilities that can arise during the sharing of data in space mission design (from phase 0 to F)
- Who is interested in cyber-attacks, why they want to attack and what they want to obtain
- Possible solutions for the protection of targets
- How to improve awareness and prevention from cyber-attacks
- The creation of a global communication model and the hierarchy of the control organisation for this model together with those responsible for successful cyber-attacks
- The levels of risk and the consequences of cyber-attacks
- The legal actions that shall be taken against those identified responsible

Discussions

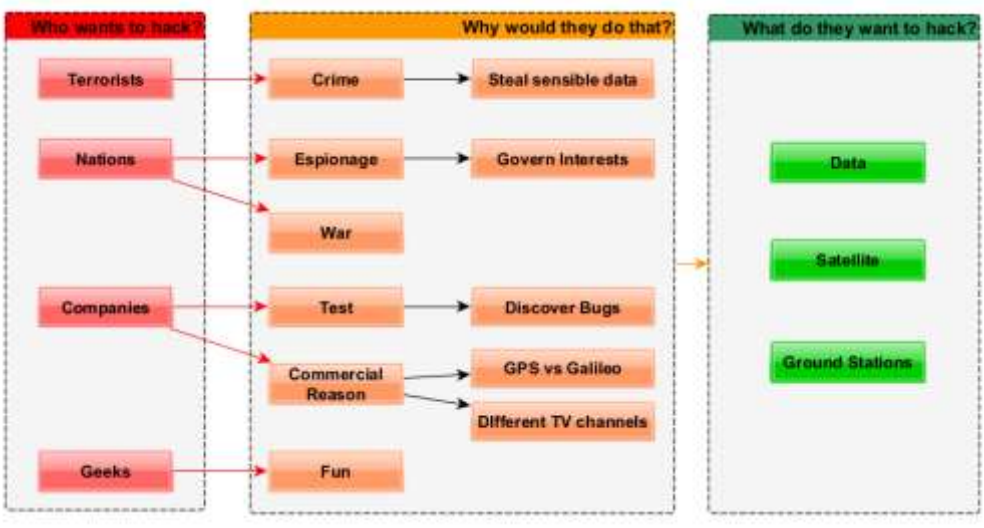
The Space and Cybersecurity Working Group was divided into three subgroups to discuss the questions mentioned in the objectives from different perspectives. These groups focused on how to bring awareness, what sort of technical measures can be taken and what sort of legal enforcements and guidelines could be helpful to prevent and to handle a potential attack.

Awareness

Awareness is the first step for protecting from cyber-attacks. To take reliable actions that can prevent from cyber-attacks, it is important to start analysing three main subjects:

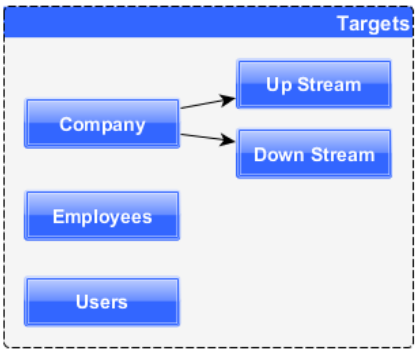
- The authors of the cyber-attacks (who).
- The reasons for the cyber-attacks (why).
- The objectives of the cyber-attacks (what).

These subjects can be summarised in the following 3W scheme



capturing the who, why, and what.

On behalf of this analysis, the group identified targets of the cyber-attacks and consequently started to discuss the actions that shall be taken in order to prevent ill-intentioned instructions from succeeding.



Being aware of the targets led to the definition of several solutions to ensure robust cybersecurity. Some examples are listed below:

- Instate different people to be responsible for security, to avoid the control and access to sensitive data, infrastructures or satellites to one person
- Data segmentation in different locations, to separate the data and make it more difficult to steal reliable data because separating them will make them useless
- Implement security certifications
- Implement different levels of security clearance

Technical Recommendations

Spacecraft programs' vulnerabilities, from a technical point of view, highly depends on the phase of the satellite lifecycle. The reasons are the changes on the number and type of system´s interfaces that are accessible from the external environment, as well as the number and background of involved operators and the nature of external connected devices exploiting these interfaces. Four main phases of the satellite´s lifecycle have been considered for the analysis of mission vulnerabilities: planning/design phase, launch phase, operational phase and end of life/decommissioning phase.

During contract bids for programmes' spacecraft preliminary design and development phases, private manufacturers and space public agencies must cooperate in a simultaneously collaborative and competitive framework. Companies must find a business compromise or solution in which individual and collective interests coexist in numerous multi-collaborative projects. During bid proposal drafts, the innovation and quality of the technical adopted solution will be of major importance. Nevertheless, the global program's cost is a main factor that will decide the bid win. Other factors will also play an important role in the technical compromise or solution that the manufacturer will present in the bid, such as the pursued final benefit or the number of implicated companies in the bid. The number and type of bid collaborators could be relevant in topics related to technical information-sharing that could bring a business strategic advantage if kept inside the company.

All the previous reasons could lead to a curtailment of the programs' technical solution. The application of innovative and extra cybersecurity measures could bring an additional cost to the program that will be avoided in certain projects. The robustness of the cybersecurity solutions adopted in this early phase of the program design could be enhanced if ESA creates a standard cybersecurity guideline for all missions, thereby cutting costs.

From the end of the manufacturing phase to the launch phase, the satellite must be shifted to the launching base. During transport and before-launch checks, the satellite will be handled by new personnel who may not belong to the manufacturing company. A basic recommendation will be to heavily screen the involved satellite operators to eliminate any human error factor.

During launch, the satellite will also be interfaced with new external devices whose origin and cybersecurity protection is not managed by the satellite manufacturer. Consequently, insurance credits for secure cryptographic systems used during the launch phase will undermine the risk of cyber-attacks through the connected hardware. It should also be recommended to implement defensive means for spoofing and jamming risks in proximity to the launch trajectory and not only the launch pad, and to always have two ground stations that are able to control the launcher.

During the spacecraft operational phase, an important security fence would be the use of virtual networks for SCC operations and big data analysis to monitor and control operator-carried procedures. It would be highly recommended to require multiple operators to upload a block-based application software that is split in different randomised uploading phases.

Concerning uplink/downlink and satellite-to-satellite communications protection, two main points to enhance have been explored. The first one relies on the use of cryptographic keys to identify the specific ground station that is doing the TC emission. The second one relies on the optical use of quantum communications when possible.

Finally, at the End of Life phase, two options should be contemplated for other in orbit satellites: a mandatory decommissioning protocol or a correct disposal of satellite, into burnup or graveyard orbits.

Legal

During the 3rd ESGW, Dr. Bowen raised the questions: *Why should government officials be concerned. How to communicate scenario to policymakers? Can we target intentional hacking using law / soft law? What does a day without space look like and could this be a possible incentive?* Patrick O'Keeffe raised the topic of national cybersecurity strategies (NCSS) commitments: *What kind of cyber operations are there? How to anticipate future cybersecurity problems?*

Nations from all across the globe, in all sorts of applications; civil, military and communication, have started to ramp up their usage of space. o ensure that this development continues in a sustainable and safe manner, international guidelines and recommendations have become a necessity.

The Working Group discussed the modern world's dependency on space systems: *Rescue operations, maritime operations, oil industry, fishing industry, whole oil supply chain put on hold when satellite communication is disrupted even for a moment, GPS systems, banking, security systems… If something went wrong who is liable?* The group agreed that a cybersecurity base package, in-line with international guidelines, should become a necessary requirement to be fulfilled by every space system manufacturer. Reasonably, it is not to ensure that a system is unhackable, but to ensure that basic precautions to make the system extremely difficult to hack have been taken.

The group talked about introducing the term *cybersecurity hygienist* to be present at every space organisation to inform all employees about main procedures to follow to avoid a breach of security in their daily work. Space companies should hold trainings in what is good cybersecurity ethics and what is not. IT departments should do health checks twice a year on every computer used within the organisation.

Space actors are at times using the same programmer for both military and civil systems, which leads to a high risk of using the same or similar code for similar subsystems. This calls for security standards for reuse of code, encryption methods and data exchange. The group also discussed physical breakings, as well as separating external and internal hacking.

Liability and penalties were the key topics in this subgroup. Having international cybersecurity requirements or protocol which each manufacturer and operator has to follow could clear the manufacturer of responsibility. This, depending on how the attack was able to get through. Introducing penalties for different sorts of attacks could serve as a preventive measure and the group discussed what would be a proportionate reaction: *Could military intervention be justified. Are we prepared to face a major attack? Is there a step by step plan? State and non-state threats, how do you trace them? Who should be the law enforcement? Should ESA, NASA, and other governmental entities define the guidelines?* The group also discussed if insurance for space systems should be recommended.

Conclusions and Recommendations

During the 3rd European Space Generation Workshop, the Space and Cybersecurity Working Group discussed how to prepare, in terms of policy recommendations and strategic guidelines, for a cyberattack in space from three different perspectives; awareness, technical measures and legal guidelines. The awareness block focused on how to prevent a breach of cybersecurity by educating academia, industry, government as well as private entities, on current and future threats. Their recommendations are as follows:

[**R1**] Improve the awareness of the people who have access to 'cyber-objectives'

[**R2**] Several types of protections shall be adopted to defend the identified targets

[**R3**] The technical block focused on how to prevent a breach of cybersecurity by defining technical measures that can be taken to lower the risks, as well as technical measures to take to regain control if jeopardised. The recommendations are as follows:

[**R3.1**] Detailed background check of all involved in satellite operation and launch

[**R3.2**] Insurance credits for secure cryptographic systems use during launch phase

[**R3.3**] Manage risks in proximity to the launch trajectory and have two ground stations that are able to control the launcher

[**R4**] The legal block focused on how to prevent a breach of cybersecurity by discussing what sort of international guidelines should be put in place covering liability, prevention and strategy through existing institutions and frameworks. The recommendations are as follows:

[**R4.1**] Put cybersecurity for civil space systems on the agenda of COPUOS

[**R4.2**] Encourage the development of international technical guidelines (non-legally binding) to make the industry more resilient to cyberattacks for civil space systems

[**R4.3**] Encourage the implementation of these guidelines on a national level

SPACE FOR SOCIETY

Moderator: Katherine Pangalos

Subject Matter Experts: Ildiko Tulbure, 1 Decembrie 1918 University, Maria-Gabriella Sarah, ESA

Reporters: Fredrik Aarrestad, Kinga Gruszecka

Delegates: Ariane Bouilly, Morgane Dussard, Victor Jungnell, Lukas Plazovnik, Romain Esteve, Gabriele Lania, Daniel Seybold, Emma Velterop, Lara Hue, Paolo Guardabasso, Adam Vigneron, Barnabás Futó, Przemyslaw Radzik, Michał Zięba, Sergio Tabasco Vargas, Florian Ruhhammer, Antonia Croitoru, Cristina Vrinceanu, Rosianu Ana-Maria, Ionut Cosmin Vasile, Andrei-Florin Balan

Introduction

Space-derived science, technologies and applications from the whole space value chain help improve the human condition in different ways and at different levels. However, society at large is typically not aware of the scope of space activities or their benefits. This is a challenge not only to space agencies that rely on public funding, but also to citizens, industry and decision makers. By failing to prioritise or utilise space optimally, they may fail to maintain infrastructures that are necessary for applications that are used by people every day or required to advance medical or material sciences. The Space for Society Working Group was asked by the European Space Agency to answer a set of questions regarding how these challenges can be solved.

Which space technologies do you see contributing the most to human development?

Before specifying what technologies contribute *the most*¸ the Working Group sees it necessary to first define different forms of 'human development'. In short, human development takes place in three stages. First, in covering basic human needs and to increase the percentage of humans for which these is met. Second, to increase the wealth and well-being of people. Third, to enable and increase innovation, which in turn may provide new opportunities and enable new paths for humanity.

The Working Group notes that while the first is by default the most essential and thus the most important, space science and technologies may very well have a greater relative value to add at the two second stages. Examples of space technologies affecting the different levels include disaster monitoring and telemedicine to help humans survive in crisis such as the Ebola epidemic and during floods and earthquakes. For the second stage, satellite applications for more effective farming, energy utilization or telecommunications all have large impacts on wealth and wellbeing. Lastly, space exploration takes humanity to completely new environments which are not only enabling but necessary to innovate and improve our understanding of the world.

Furthermore, the Working Group notes that space is a system of systems where it is difficult to separate technologies and their implications. There would be no satellites providing applications without reliable and efficient launchers, and the current commercial and public space programs would not be the same without previous efforts to master access to and familiarity with the space environment which we have obtained thanks to space science and exploration. It is therefore difficult to single out a single technology most important to human development. Instead, our collective effort to explore and utilise space ought to be viewed as an endeavour to obtain knowledge and excellence

for mankind, on which many innovators across the world can build technologies and applications to improve human development.

How do we make clear the socioeconomic benefits of space applications to potential users?

Today, space affects the vast majority of people living in different corners of the world. Since the benefits and influence are often highly indirect, such as the products and services we consume becoming more affordable or safer and more reliable, or space-derived knowledge forming the basis for innovation only years after the exploration or science mission enabling it took place, measuring socioeconomic impact, let alone communicating it to the public, is difficult if not impossible. To approach the question, the Working Group suggested distinguishing between different groups of end users and stakeholders benefiting from space applications. These were first the general public, second the private sector and industry, third governments and decision makers, and lastly academia and research institutions. Since these groups benefit differently from space applications and technologies, different messages or forms of communication should be used to address each individually.

For the general public, it is necessary to increase awareness of how space applications are a key infrastructure similar to roads and other public services. This means educating people on how satellite data, communication links and signals are indeed requirements for many daily services which each and every one of us use. Beyond this, it is important for people to understand that while satellite applications providing services to Earth may look more relevant to them, these are in the end only available thanks to prior investments in technology and expertise in space science and exploration. Indeed, space exploration provides the only arena where many existing theories in the fundamental sciences can be put to the test, or where new theories can be formed on the basis of new discoveries. Beyond an awareness of the usefulness of satellite applications, space science and exploration ought to be viewed as equally important. To successfully reach the general public, the Working Group looked at different ideas, the first of which was for space agencies to form and state a more tangible future goal. As space, being a system of systems, affects us indirectly in so many ways, educating the population on all aspects may not be realistic. However, having a clear goal for where to go next and what to accomplish on the way may make the job easier. An example could be the vision of a lunar base, which is a concrete objective.

In the case of industry, there is still a need to raise awareness of how space activities spin off technologies that can be transferred to non-space companies. Very few small and medium-sized businesses are aware of the opportunities that they have to work with the space sector both upstream and downstream, or how satellite-derived data might help improve the quality or efficiency of their products or services. Likewise, decision makers and public organisations could also make use of space data to improve environmental monitoring, urban planning, traffic management and public safety. The Working Group discussed different ideas for making space and satellite applications better known and understood in non-space industries, as well as for the public sector. One idea was to have a ‘Made in Space’ label of products and service that rely at least partially on one or more space applications. A second idea was to improve upon how good practice examples and experience is exchanged between non-space end user groups (i.e. good practices database of EURISY).

For academia, space takes not only most scientific and technical disciplines to new environments, but it also provides new perspectives and poses new questions relevant to the humanities and social sciences. As an interdisciplinary environment, space ought to engage with researchers and academic professionals across different fields of excellence. For that, it is important that the current missions taking place are understood also by professionals in other fields who might then propose research relevant to relevant questions and concerns. For instance, as more private companies are aiming to use resources in outer space, or to send humans on one-way missions to Mars, questions will be raised that belong also to non-technical fields.

How should space agencies frame their Earth to space missions to ensure the public perception of their utility, and thus their long-term support?

Building on the idea that by having a clearer vision and tangible goal for space, people can better relate to and understand the value and purpose of space activities, missions ought to be framed according to the tangible future goal. This will ensure that people see how the mission relates to the overall objective. Learning from SpaceX, everyone now knows Elon Musk's goal of making life multiplanetary and making access to space more affordable and scalable. Thus, people who follow SpaceX and watch their launches quickly see how a new launch that tests new technologies or payloads relates to those objectives and thus has a utility and value. As a result, when a mission occasionally fails, people will see failure is part of the road to success and comes with valuable lessons learned.

More can be done to popularise and brand space activities. For example, using more of a storytelling approach when doing communication, which can include movies, comics, books, and music (i.e: Philae/Rosetta cartoon, *Dans la combinaison de Thomas Pesquet*, Rosetta album by Vangelis). To deliver this, more artists and creative professions could be involved in the promotional activities. The resulting message ought to emphasise the human connection, which astronauts already communicate well when they talk about how there are no borders visible from space, or how cosmologists remind us that in the end, we are all made from the same stardust.

Another suggestion from the Working Group was to have more flexible copyright policies around the use of the ESA logo and other sigils from space missions. People are happy to wear clothing or buy mugs with the NASA logo on it, which is also visually pleasing. With the belief that space belongs to all of mankind, that space activities are a collective endeavour, and where most space agencies are still owned primarily by the public, the population ought to feel more ownership and a desire to represent and cherish space. Lastly, the space organisations should consider a modernisation of communication channels to then bring a collective vision with a strong visual identity to the public.

What can ESA or the EU do to promote the growth of the space sector in emerging markets?

Space science and satellite-derived data are by default global and as such are applicable, if not more so, to developing countries. In the case of services relying on satellite data, most can be developed and delivered from any country on Earth, to any other as the data (especially in the case of Copernicus, which is free) can be accessed from anywhere. As an example, a young startup consisting of IT students in Europe could provide services to optimise farming, forestry or traffic monitoring in any city in Asia, Africa or elsewhere. Likewise, countries that may not yet have a strong upstream space sector may still have a new abundance of young software developers and programmers who could help grow the space sector by creating new products and services based on its downstream applications.

To make better use of this opportunity, there is a need to engage more strategically with younger generations. This may be through activities such as the ESA Teacher Workshops, increasing the number of free online classes (i.e: Coursera, EdX, futurelearn), or to bring a space dimension to hackathons and StartUp Weekends. This way, even if no tangible product is made during an event, new and innovative minds seeking to build new products and services or solve global challenges are now aware of space data, where to access it and how to use it.

With developing countries representing one of the largest emerging markets for earth observation services in particular, ESA, and the European Commission (EC) should do more to incentivise European entrepreneurs to solve problems abroad in emerging economies using space-derived data and technologies. This would both result in growth in the European economy as well as creating more demand for space technologies and data. To achieve this, one could consider the creation of targeted funding for small to medium enterprises (SMEs) and startups aiming at providing services to

emerging markets. Another idea was to open ESA Business Incubation Centres (BICs) focused on a particular non-space theme (i.e. agriculture) of interest to the local market in the specific country. Finally, with new and open satellite data providing opportunities to more and more actors also outside of the traditional space environment, it is increasingly important to ensure that the entry barriers are low. This could mean facilitating the procedures to answer a tender call.

In short, one must ensure that creators and solvers in emerging markets are aware of what toolkit space provides them with.

What opportunities for space cooperation (with economic sectors, nation-states or international organisations) have yet to be fully tapped into by ESA or the EU Commission?

The Working Group was in firm agreement that international collaboration in the form of exchange of knowledge and expertise, as well as joint missions, benefit all countries involved. Indeed, the innate ability of space to build and maintain bridges between countries over time, regardless of political climate here on Earth, should be seen as a benefit of space in and of itself. As a result, both ESA and the EC should have a clear goal of building new and stronger collaborations with emerging space nations' agencies whenever applicable.

Space agencies, and international, regional space-related organisations (i.e. African Union, CARICOM) should also be engaged. As space agencies seek to better communicate and demonstrate the socio-economic benefits of their activities as discussed previously, such collaboration can also benefit ESA and the EC, as connecting with non-space organisations helps demonstrate this also in practice. While collaboration projects already do exist with European schools, universities and related networks, this could be expanded on in other countries as well. Lastly, global non-space organisations/sectors (e.g. NGOs, health organisations, etc.) should be included.

The goal should be to identify markets and research fields that have a focus on ensuring global sustainability in which space applications can provide value to achieving the sustainable development goals of interest to the organisation. The Working Group also stressed how space agencies and the EC could work closer with regional organisations in member states. In many of these countries, regional development agencies and innovation clusters are not fully aware of the mechanisms through which their local industry or public services can apply for funding to develop or implement space-based technologies and applications.

Conclusion

Space now touches most people's daily lives directly or indirectly. As time goes on, this is more likely to increase as new space applications find its way to complement and improve existing services while space-based research and science enables new innovations to occur. For this development to continue in the right direction, it is important that people and decision makers are aware of the current missions and activities taking place in space and why they matter. To improve such awareness and gain the support of people, space agencies and institutions ought to have a clear and positive vision and set concrete and tangible goals for activities that enable it. By bringing together new actors from other sectors, and demonstrating its unique ability to unify humanity to solve the biggest challenges on Earth whilst pushing the greatest barriers outside of it, the space sector can achieve higher recognition and support for its work. Space agencies and institutions around the world are working to improve the lives of people around the world in the present while providing new opportunities for the future. With this in mind, together with the need for experience and knowledge from other sectors, space agencies should think beyond what space can do for society, to also ask what society can do for space.

SPACE EXPLORATION

Moderator:	Laia Ramio Tomas
Subject Matter Experts:	Marco Crisconio (ASI), Jakub Knir (Foster and Partners), Christian Ohlendorff (Mars One)
Supporting Subject Matter Experts (2nd day):	Franco Fenoglio (TAS), Andrea Pellacani (GMV), Kyle Acierno (iSpace)
Rapporteur	Zoe Townsend
Delegates:	Adam Szilvassy, Caroline Amiel, Akash Trivedi, Antonino Salmeri, Charlène Doucet, Sindre Forsetløkken, Maria Grulich, Harriet Gamble, Laura Miquel Parra, Katherine Page-Bailey, András Ordasi, Vilde Rieker, Isabel Moore, Andrew Butler, Jekaterina Timohhina, Pol Sola Romeu, Karen Mak, Karoly Schlosser, Daniel Wischert, Beatriz Pisoni, Emanuel Moraru, Simona Anca, Laurentiu Nicolae, Cristina Stancu

The Working Group was formed by 25 delegates from different countries and backgrounds, with a total of six supporting subject matter experts, to discuss together the future of space exploration. On the first session, we started with a common brainstorm where we all shared our views in the domain to identify the topics to discuss in more detail. For the rest of the sessions, we were divided in four sub-groups. The subject matter experts raised multiple questions and discussions, each of which was treated in parallel by two of the sub-groups.

This way the conclusions and recommendations from the two sub-groups that treated the same topic could be contrasted to find the areas with general agreement and those with more diverse opinions.

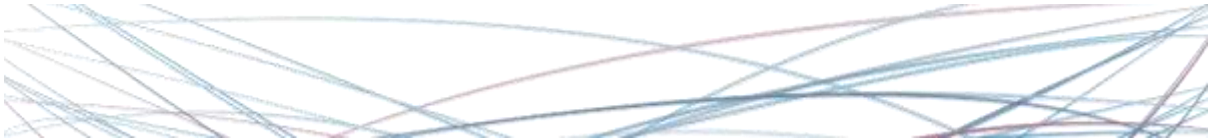
Our key objectives were to discuss the future of human spaceflight for space exploration, and how technology development for space exploration may change if private companies get involved in the activity. The main questions that were raised during the workshop are:

How shall the space exploration activity be treated now that private companies are showing interest in it for their profit? Shall it be a free market?
How important is the legal frame for the future of space exploration?
What should the agencies focus for the next human mission once the ISS programme is over?
Should low Earth orbit (LEO) be kept with human presence?
How we envisage potential settlements in the Moon or Mars?
How will the workload be shared between humans and robots human space exploration?
Should we engage the general public in space exploration? How?
Will space exploration bring peace?

Future of Space Exploration:

How important is legal frame for the future of Space Exploration?

With increasing market presence of private companies, space exploration is changing. Legislation needs to be discussed to understand the limitations of these private companies and if they must comply with current international space law. Should the sector be treated as a free market, allowing private companies to operate as they will, or should there be a strict and protective legal frame?



Recent announcements about the possibility of asteroid mining have made the whole space community consider the legal framework for private investment in space. Some countries such as the USA and Luxembourg have interpreted the international treaties in a way that permits asteroid resources exploitation for economic benefits.

Without legislation in place there are polarising views as to the future outcomes from privatised companies. One opinion is that if companies can see profit in space exploration, even without legislation, they are likely to invest in it and develop new technologies. These new technologies can then be reused for other missions. However, countering this is the opinion that without legislation investment could be seen as risky. Therefore, would technology development be halted until there is a clear legal frame for it?

In general, most delegates believe that whilst legislation is being discussed, technology should be developed in parallel to find out technological limits before establishing political limits (figure 2). Getting resources from space will surely impact the current economic system, but most delegates don't think that this should be a showstopper, it should be taken as a new industrial revolution and the world needs to get ready to take the most of it. Controversially, it should be noted that most of countries that rely on Earth mining for their economy do not have access to space exploitation, therefore the future legislation should consider limiting the disruption to these countries' economies.

Currently the subject of legal framework in space is largely discussed in conferences. However, there is no real push to create international laws that define the limits of space exploitations and to ensure fair competition amongst all countries. What everyone agreed on, is that international organisations should push the creation of an international legal frame that clarifies the limitations of space exploitation as soon as possible. Engaging with public voters and companies to push for legislation would encourage the politicians to push for legislation and framework.

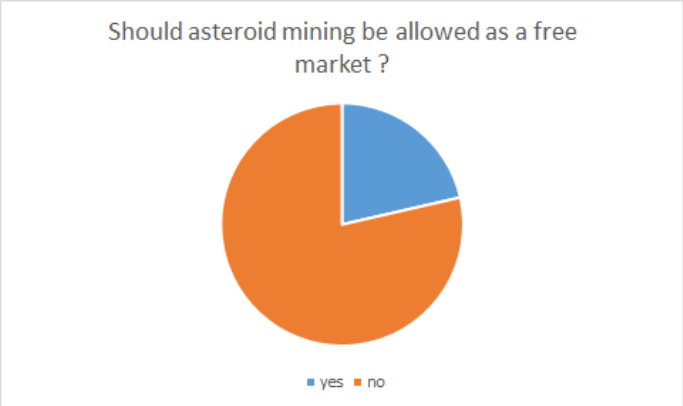


Figure 1. The opinion of the delegates on asteroid mining

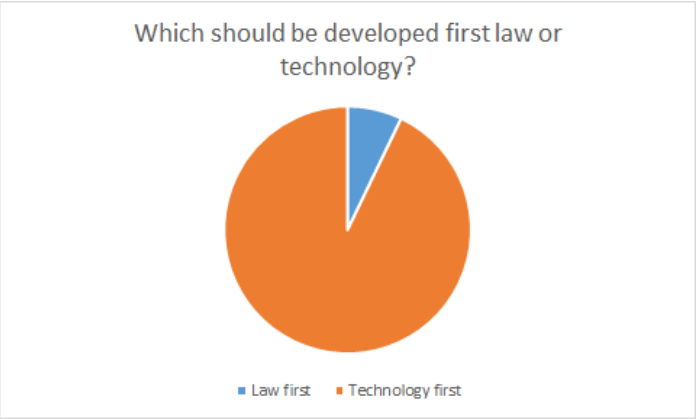


Figure .2 The opinion of the delegates on if law or technology should be developed first

What are our future suggestions for the ISS and should there be a continued presence in LEO?

The ISS mission is due to end within the next 10 years, whether or not keeping a similar mission is possible or wanted is delegated by the funding from the member states. Given that the budget for the agencies is limited, the current plan focuses on expanding the boundaries of human spaceflight.

However, we believe that dismantling the ISS and leaving LEO unoccupied would be an error. Our main reasons are summarised as:

- A permanent human base in space is considered an intermediate step for tests and technology demonstrations to get ready to send humans to the Moon and Mars.
- A base on the Moon or Mars won't enable the performance of microgravity experiments.
- Trying to do such experiments during the trip to the Moon or Mars is an ideal scenario but possibly not feasible, because optimising one mission for two finalities which are quite different from one another would represent very high costs.

An example of a dual-purpose mission is one such as the Deep Space Gateway, a human based lunar orbiter that would be an option to have a sole mission used for micro-g experiments and at the same time, to get humans closer to having a Moon Base.

With respect to the future of the ISS, the most common opinion is to privatise part of it, so that agencies can use the revenues to fund other space exploration missions. Its modular architecture can be used as an advantage to keep part of it for the agencies and let private companies exploit other modules, either for private research or for space tourism. In terms of private uses for LEO, space tourism is thought to be the one that will consolidate faster.

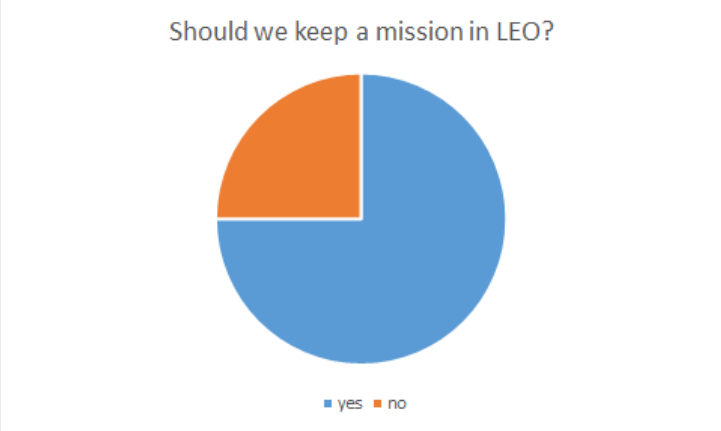


Figure 3. The opinion of the delegates on keeping LEO with human missions.

Should the Moon and Mars be kept as scientific only bases, or will villages eventually develop outside from Earth?

Although in the past few years the focus of agencies appears to suggest that Mars would be the next objective of human spaceflight, most agencies are now focusing on going to the Moon again. This is seen as a logical step. The Moon is closer, so it can be an intermediate step to master the technologies and create a Moon base that will then allow deeper exploration. However, investing in the Moon now also means that human spaceflight to Mars will be postponed.

In general, most of the participants see the Moon having a base instead of a village, mainly used for scientific purposes and to facilitate human spaceflight to Mars (figure 4). On the other hand, the options about Mars are more varied as most people can imagine a Mars Village, where in the future people that go there may remain there for very long time, or even a lifetime, and hence a whole society shall be constructed around it (figure 5).

Regarding public or private exploration, the question raised is: why should the member states support a Moon base or village? How could a politician be convinced that investment in space exploration should receive part of the budget from the country? The first answer that came up is about prestige, making Europe be a leader instead of a follower. There is also the fact that going to the Moon and Mars represents new challenges for sustainable environment, which can lead to the development of new technologies that may then be useful for the Earth. However, the general belief is that if space exploration depends on the agencies only, it will take much longer due to bureaucracy and politics around the mission. Plus, Europe is currently in a delicate position: it does not have a launcher of its own that can deliver humans to space, it currently needs to partner with Russia, the USA, or China.

However, private companies will only go if there is an economic interest to invest. If there is, that may represent more investment and a faster development of the technologies needed. On the other hand, private investors benefit from exploring the celestial bodies. The introduction of private companies would require new laws and legislations for the ethics and legality around their activities.

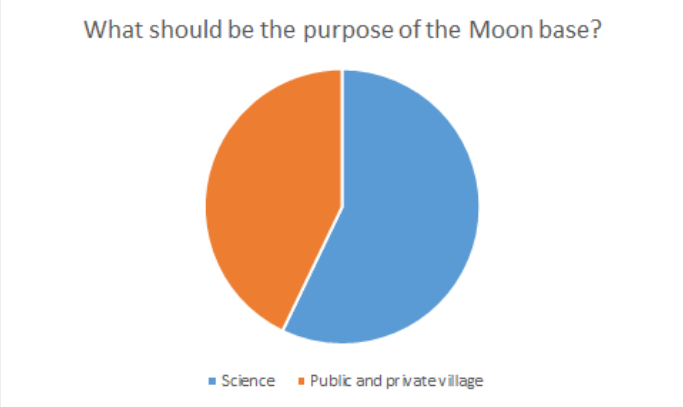


Figure 4 The opinion of the delegates on the future purpose of the Moon base.

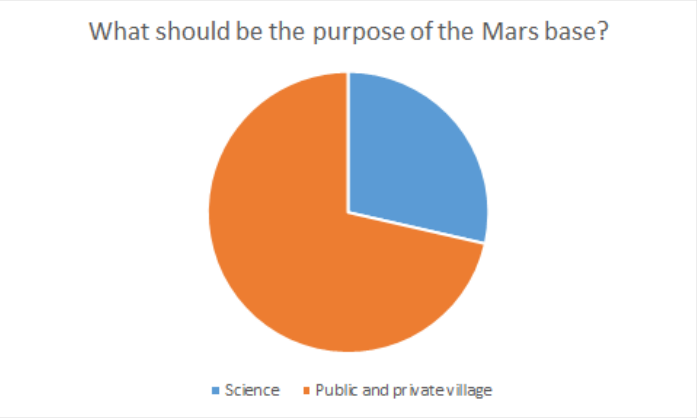


Figure 5. The opinion of the delegates on the future purpose of the Mars base

In general, it is believed that private companies will wait for agencies to make the first step before starting big investments in human space exploration. But involving private companies is beneficial for everyone; the competition would encourage more development in technology. Space X, for example, has had a positive impact for ESA because the competition has meant a redesign of Ariane 6 capabilities to be more cost efficient.

In the future of space exploration how would the workload between humans and robots be split?

Human space exploration brings an undeniable risk to astronaut lives, long term space exploration would require the development of numerous technologies to prolong missions. Humans have weakness that robots don't, such as medical or nutritional needs. These needs are addressed and therefore not viable for long term space explorations. This means that more technological development is needed before being ready to send a human mission to Mars.

The conclusion of the delegates was that in case of settlement robots should go first to prepare the area and set up the equipment, followed by humans to build up the settlement. Once a base is established, they will share the tasks, with robots being 50-80% of the mission crew. This represents that the research and development of robotics shall also be pushed to ensure that they have maximum autonomy. It was also pointed out that the whole process of starting a settlement should be preceded by a human mission to have a first recognition of the area, as humans have a faster reaction time, they can take decisions and explore at a level that robots cannot reach yet.

This is thinking mainly for a scientific base. For different applications, the proportions would then change. For instance, in the case of asteroid mining, it shall be mostly robots whilst in applications like space tourism, focused on giving a service, there will be more need for humans.

Space Exploration and Society

This topic has come up in more than one discussion, highlighting that one of the positive things about human space exploration is that the research to create sustainable environment in other celestial bodies may then have applications and benefits for the whole society on Earth.

Why should the public engage with space exploration? How can the public be motivated to support these ventures?

The common agreement among the delegates is that the general public should be engaged with space exploration. Europe should make a bigger effort to engage the general public with space activities in general, including space exploration. Elon Musk's attitude is that if people are more excited about science then the likelihood of investment into science increases. Following this, Kyle Acierno's presentation on how iSpace got to engage investors is aligned with that motto. This is also true for pubic missions: public excitement cannot be underestimated. Politicians are interested in public excitement, and hence, they will be encouraged to fund what the public supports.

Many people are not aware of what has been going on in human spaceflight since the first Moon landing, and this should be changed. ESA did a big campaign for Rosetta and the mission was shown in schools, which was a good introduction to space exploration. More campaigns like Rosetta should be encouraged to let people know how ESA contributes to space exploration and this could potentially allow public engagement.

The American approach is quite different from the European one, more people know about NASA and Space X than about ESA. The recent launch of the Space X roadster engaged people that typically have no contact with the space industry. However, this was an expensive campaign that had no benefit for the public, so a public agency could not, and should not, do this sort of publicity. Instead, agencies should focus on campaigns, events, conferences and centres where people can learn about the space sector, like what was done for Rosetta.

This communication should target the younger demographic so that they grow with the idea of exploration. Organising big events to present the missions and the benefits for society can show the general public understands why space exploration it is important. Creating a STEM park based on space would have a large impact, such as the Cité de l'Espace in Toulouse but in multiple European cities.

Aside from the communication on the attractive missions that are being developed, all groups also agreed that more awareness should be given to the population about the threats coming from space and the solutions under investigation, so that they can also understand why money is needed in the area.

Do we think that space exploration will lead to a society with cooperating countries? Will it bring peace?

The ISS has proven how an international venture in human spaceflight eases the relationship between participating countries; a common project for which they have to collaborate. The same can happen when going to Mars, it won't bring peace to the world or stop wars, but it will promote the collaboration between countries. In new human spaceflight ESA programmers, an effort should be made so that all countries are part of it, even with small contributions.

We have the vision that a settlement out of Earth will be based on a better society organisation, with peace between all inhabitants. Ideally, it should be treated like an international area, as the Antarctic, where astronauts from different countries go there together and live together. However, history shows a tendency in human beings to create disputes. If there is a community based in Mars for long term, or even a lifetime, it is inevitable to think that new ways of political organisation may be needed.

As the community grows, in an eventual future with Mars villages, they may need to trade with the Earth, and get resources. It is important that the relation between Mars and Earth remains healthy and villages there are not treated as colonies.

Conclusions and Recommendations

[**R1**] International legislation for space exploration should be developed with maximum priority to regulate new activities and to support the growth of new players.

[**R2**] LEO Orbit should continue to have human missions to ensure that there is continuity after the ISS for micro-g experiments and for tests to go into deep space missions.

[**R3**] The use of the ISS should open to private companies so that the agencies can use the money for deep space exploration. LEO is the ideal orbit for space tourism, and the modular configuration of the station will enable separating scientific areas from tourism areas

[**R4**] The next human program should start soon to ensure that there is no gap after the ISS, which could cause the loss of knowledge and experience acquired. It is important that all agencies are together in such program, so it makes sense that ESA targets the Moon for next human missions to align with the strategy of NASA.

[**R5**] To reinforce international cooperation, ESA should try that all member states are participant of the next human spaceflight program, even if it is only with small contributions.

[**R6**] The Moon shall be kept as a scientific base, coordinated at international level, like the ISS, with cooperation from all agencies.

[**R7**] Mars, on the other hand, can be explored with the concept of villages.

[**R8**] Agencies need to cooperate with private companies and include them in the roadmap, as competition will help faster technology development. Most delegates believe that the first mission to land a human on Mars will be private, or partially private.

[**R9**] Research funds for space exploration should also support the development of robotics, as in the case of a scientific settlement it will be crucial to have a shared workload between humans and robots, with about 50-80 % of the tasks being performed by robots.

[**R10**] It is important to engage the general public with space exploration missions, especially with the work done in the ISS, which most people are not aware of. Presenting the threats from space so that people is aware of them is also important, together with the solutions under development.

[**R11**] The outreach/promotional projects funded publicly should have a different approach that private publicity, as they should also be a service for the public. It should be in a sort of informative way allowing everyone to learn about space exploration, such as Rosetta campaign or a park like Cité de l'Espace.

EMERGING SPACE – INTERSECTION OF PRIVATE AND PUBLIC PLAYERS

Moderator: Eloise Matheson

Subject Matter Experts: Mansoor Shar (Inmarsat), Jarosław Jaworski (PIAP Space)

Rapporteur Lorenzo Pasqualetto Cassinis, Maximilian Scherer, Antoine Bocquier

Delegates: Alvaro Morejudo, Andrei Sapera, Augustin Colonna Walewski, Daniel Sors Raurell, Dennis Daub, Eduardo Bressel Baratto, Eugenia Malevanciuc, Florian Marmuse, Francisco Garcia Lacarte, Helena Carre Martell, Iulian Juhasz, Ivan Sumelzo Martinez, Jędrzej Kowalewski, Julie Mottin, Julie Mottin, Kirstine Thomsen, Maksymilian Sidorowicz, Mat Dawidowski, Mihai Golu, Mizuki Tani Hatakenaka, Roland Karger

Introduction

Following inspiring presentations by several entrepreneurs from private space companies, 25 participants formed the Emerging Space Working Group to discuss the development of private investment in space activities. The Working Group consisted of representatives from across Europe with diverse backgrounds. The organisation of the workshop started with a preliminary brainstorming session where we clarified our objectives for the workshop, and narrowed down our initial, general discussions to three core topics.

Our key objectives were to:

- Discuss the role(s) of the private/public organisations in the space sector
- Identify how the nature of business in space has changed, with specific comparison of US and EU markets
- Consider how to foster a strong and sustainable market for start-ups and new business developments
- Identify future trends and key enabling technologies
- Identify which emerging space markets hold the greatest threats/opportunities
- Consider initiatives to involve private players in space debris management

Considering that new trends, technologies and business models are changing the traditional role of governments and public space agencies in the space sector, Public Private Partnerships (PPPs) were identified as a key cooperative arrangement. These collaborations can create an environment where knowledge and capability is more easily shared. Technology innovation can lead to a redefinition of business opportunities between the public and private sectors, so future technologies were also identified as a key factor that can potentially disrupt the emerging space market. Finally, the importance of identifying the role of space agencies from a legal and engineering perspective was related to the broad topic of space accessibility and the future space debris economy. Splinter groups were formed to discuss these core topics.

Startup Support and Public Private Partnerships

One of the core elements of the Emerging Space Working Group discussion was the support of startup companies in the space sector and the concept of public-private partnerships (PPP).

The dialogue began with an examination of the highly successful NASA COTS (Commercial Orbital Transportation Services) programme, an initiative to promote PPPs with American companies to resupply the International Space Station. How does Europe ensure it is not left behind, and keeps the European industry attractive in an increasingly competitive market? There were those in the group quick to point out ESA's Business Incubation Centres (BICs), originating from the Technology Transfer Programme Office (TTPO). Although the BICs have a proven track record of supporting downstream application start-ups, they tend to be less well adapted to backing upstream businesses. It was suggested that the BIC framework for upstream applications needs to be different from the one that is currently operating.

An ESA Consulting Office, a natural extension of the BICs, was touted as possible additional support network for space sector start-ups. The idea was developed during further discussion and the concept of *intrapreneurship* proposed: ESA could allocate some free time to their engineers to advise startups (both technical and business oriented), or to innovate and work on personal passion projects related to the space industry. Google is a company known to embrace *intrapreneurship* by offering their workforce a 20% time allocation to develop their blue-sky ideas (or to work on someone else's). Gmail, for example, was one such project. There are also examples of this concept being applied in the aerospace industry, such as Airbus' BizLab and to a small extent within Europe's space agencies.

A brainstorming session was initiated to analyse what the emerging private space sector in Europe likes about ESA and also how the agency's approach could be improved. SGAC members thought elements of ESA which deserve particular praise include:

- Broad visionary goals which the agency offers
- International representation for European companies (especially smaller businesses)
- Society outreach programmes
- Current non-military stance.

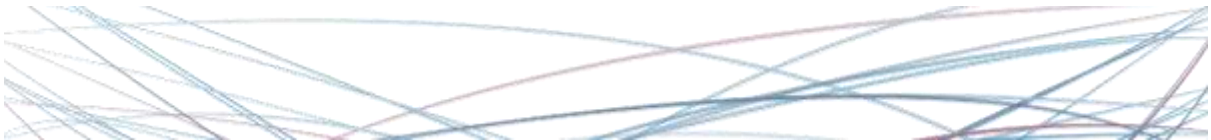
To highlight some aspects which could be improved:

- Flexibility - less paperwork, faster decision making
- More support for early stage initiatives and upstream space tech startups
- Sharing of knowledge and information/data (e.g. expired patents)

The workshop explored the nature of private businesses in the space sector and how ESA could best support fledgling start-up companies. There was a broad consensus that more guidance and training (although not formal lessons) from ESA would be beneficial to both 'established' startups and those considering entering the field. The guidance aspect could take the form of technical consultations with ESA experts, or experienced personnel who come on-site to advise.

One key point which came up during a splinter group conversation was the idea of branding, in particular the ESA brand and the respect which investors have for it. ESA could implement a 'Stamp of Approval' for select startup companies which have a useful product and a sound business plan, to help them generate brand trust and recognition. This easy to implement quality stamp, based on an award and not necessarily including financial support, would assist worthwhile start-ups in attracting private investors.

The aversion of investors to perceived risk in the space industry could be further improved by putting in place solid regulations and legislation concerning space activities. Potential investors are keen to have a regulated framework of space law in place before committing capital to a project. It is the opinion of the Emerging Space Working Group participants that the process of enshrining space law is progressing too slowly in Europe. As well as comforting investors with a strong set of laws, sensitizing venture capitalist to the space industry and educating them on space matters could increase

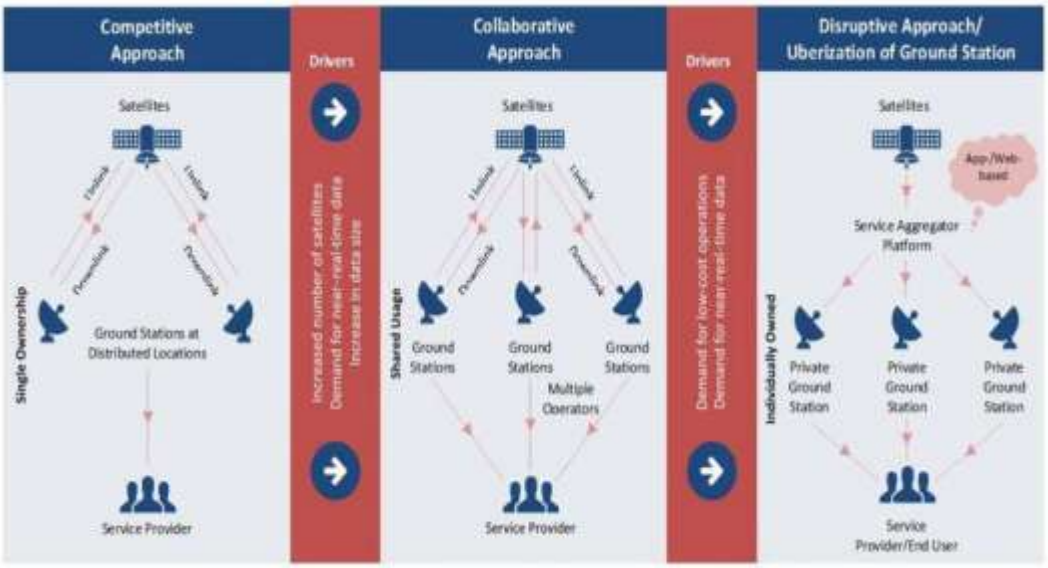


investment in the sector. Policies such as these, which have proved to be effective in the US, may lead to new opportunities and could further open the European market to emerging space industries.

The future of private initiatives in space is bright, especially with the emergence of enabling technologies from recent research and development successes. New trends in space access, hardware design and manufacturing is lowering the barrier of entry, particularly for small players, and more and more applications are being addressed with space-based solutions.

New Trends and Key Technologies - Emerging Markets

The second discussion was around trends in the space sector and key technologies that lead to emerging markets and actors. Recent years have seen major changes as privatisation and investments rose strongly, in areas such as launching to the operation of mega constellations of satellites. Such investments came from big companies or Venture Capitals able to risk major capital in a field where agencies have long been the leading players. Cost-competitive launchers, mainly based on reusability concepts, and the miniaturisation of components as well as private public partnerships (e.g NASA COTS) led to the development of smaller, cheaper, more frequently launched satellites with lower requirements and lower lifetimes, allowing continuous R&D pipelines. From major companies to startups (RocketLab, PLD Space, OpenCosmos) or space laboratories (ONERA), providing low-cost launches for small payloads is a priority for space democratisation, illustrated by a 158% increase of small satellites launches in 2017. The wider use of satellites may also lead to the need for autonomous ground stations, as demand increases and private operators emerge. Moreover, communications by optical (laser, near-IR) communications, space to space and space to ground, are promising technologies that are likely to be game changers.



Space-linked markets grew as more space data-based services and products (downstream applications) emerged in many different fields: transportation, agriculture, maritime, rescue, mapping and urban planning are only a few examples. In addition, this data economy has been made more accessible to smaller companies and end-users.

Space exploration has also received a new boost as private companies show more interest (SpaceX, Blue Origin, iSpace), supported by agencies (Moon Village concept by ESA) while legislation is also developing. From space mining to settling on the Moon or Mars, key technologies include robotic progress via artificial intelligence, machine learning and the use of big data to help design, process and capitalise on missions. Construction or mining requires robot-human cooperation and is likely to be driven by 3D printing and ISRU (In-Situ Resource Utilization) technologies such as extraction,

processing, manufacturing, micro-factory, blockchain or energy production. Analog missions (NASA, Mars Society, OeWF, COMEX) already give the possibility to experiment with these technologies.

Lastly, suborbital and orbital flights have created new markets: from suborbital tourism with Virgin Galactic or Blue Origin to orbital hotels, developments are coming closer to commercialisation while scientific experiments or transcontinental transportation are also considered. In Europe, ESA Space Rider (developed by Thales Alenia Space) aims to create a scientific orbital platform. Moreover on-orbit servicing (refuelling, maintenance, debris removal) has gained recent attention as satellite use is expanding and the case for on-orbit servicing is being strengthened. The space debris economy case area was highlighted for further discussion within this workshop.

Space Debris Economy

The profitability of the Space Debris sector was addressed by analysing the current regulatory environment as well as the future opportunities in the field of Active Debris Removal (ADR).

The initial part of the dialogue consisted in addressing the current state-of-the-art in Space Debris Mitigation. The common belief was that the current regulatory environment is very weak and fragile, as there are only a few existing guidelines that need to be respected. For almost 40% of the satellite in LEO [3], their companies do not apply mitigation strategies. The large percentage can be explained by the economical disadvantages in undergoing Space Debris Mitigation, especially in the presence of unclear guidelines and the fact that there is no legally binding legislation under international law. As such, it was believed that the current mitigation guidelines should turn into regulations in order to guarantee a proper and clearly defined regulatory environment. Perhaps looser regulation in CubeSat companies should be avoided, given the fact that the same regulations should be valid disregarding the size and cost of a satellite. Furthermore, it was suggested that ESA should provide private companies with an updated space debris catalogue for Collision Avoidance Manoeuvres (CAM), as an increased awareness of the Space Debris Mitigation guidelines could incentivise further investments in the space industry and lead to a higher awareness of the space debris problem.

The workshop further explored the opportunities, as well as the responsibilities, that can result from the participation of private initiatives in ADR activities. The general idea was that public entities can take full benefits from the current trend of leaving the development of future technologies to the private sector while preserving a regulatory public entity. In particular, a consideration was made about the fact that a high-level organisation should take care of ADR regulations, in order to make space activities profitable for private companies. The general idea was that an entity like ESA, or a similar high-level organisation, cannot disappear simply due to the fast growth of startups, because in the debris mitigation field such an organisation will certainly be needed. Otherwise, without a regulatory entity, it will be almost impossible to follow an active debris removal approach - and thus see private participation in ADR activities, because the construction of the regulatory framework underpinning it cannot be easily tackled by private companies.

Conclusions and Recommendations

After a very fruitful two-day discussion summarised previously in this report, we can conclude with the following key recommendations.

[**R1**] Early stage initiatives and upstream space technology start-ups need to be better supported in Europe, and ESA can take a lead role in this. This could be via intrapreneurship advice and support, the creation of ESA Consulting Offices for upstream technology, or the creation of a ‘Stamp of Approval’ for selected startups.

[**R2**] New technology trends hold opportunities for growth in the space market for both new applications, and disruption of old practises.

[**R3**] Public organisations need to be responsible for creating regulation, legislation and frameworks for the activities of private players in the space market, which supports, rather than restricts, their growth in a sustainable fashion. This is particularly true in the area of space debris mitigation.

ACRONYMS

Space Generation Advisory Council	SGAC
European Space Agency	ESA
Centre National d'Études Spatiales	CNES
Agenzia Spaziale Italiana	ASI
Romanian Space Agency	ROSA
International Space Station	ISS
Internet of Things	IoT
United Nations Committee on the Peaceful Uses of Outer Space	UN COPUOS
European Space Policy Institute	ESPI
German Aerospace Center	DLR
Romanian Office for Science and Technology to the European Commission	ROST
Romanian Association for Space Technology and Industry	ROMSPACE
Fluid Structure Interaction	FSI
American Society of Mechanical Engineers	ASME
Committee for Liaison with International Organisations and Developing Nations	CLIODN
International Astronautical Federation	IAF
Institute for Security Policy at Kiel University	ISPK
Centre of Excellence for Operations in Confined and Shallow Waters	COE CSW
Non-Government Organisations	NGO
Government Organisations	GO
International Government Organisations	IGO
Asteroid Impact Mission	AIM
Analogue Astronaut Mission	MDRS
Computational Fluid Dynamics	CFD
European Commission	EC
Business Incubation Centre	BIC
Low Earth Orbit	LEO
Public Private Partnerships	PPP
Commercial Orbital Transportation Services	COTS
Technology Transfer Programme Office	TTPO
In-Situ Resource Utilisation	ISRU
Active Debris Removal	ADR
Collision Avoidance Manoeuvres	CAM

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