# REPORT OF THE 6th SPACE GENERATION FUSION FORUM

## 2nd and 3rd April 2017

SPACE GENERATION
ADVISORY COUNCIL

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**Sponsors and Partners**

The Space Generation Advisory Council (SGAC) is very grateful for the continued generous support of sponsors and partners. This year, SGAC's sponsors and partners expanded both their financial and intellectual contributions, which has played an important role in the improved quantity and quality of the output in 2017. SGAC would like to thank all sponsors and partners once again for their contribution to one of the most successful years in SGAC history.

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Letter from the SGAC Chairs

It is our great pleasure to present you the report of the sixth Space Generation Fusion Forum (SGFF) in Colorado Springs, USA, held on 2nd and 3rd April 2017. The event gathered 60 students and young professionals from 11 countries who discussed a diverse range of topics. In order to enhance the discussions, five focused tracks were organised, and experts in this field were invited to moderate and guide the attendees' discussions. We are very glad that we could invite selected SGAC members to join us at the SGFF through the Global Grant scholarships. The winners were selected based on their experience and relevant backgrounds. We would like to thank our team of highly dedicated volunteers whose work is the reason for the ongoing success of the Fusion Forum, especially the exceptional leadership of Alexander Gibson, Space Generation Fusion Forum 2017 Manager. This event would also not have been possible without the dedication, planning, and motivation of the organising team. Our special thanks go to the Space Foundation, who hosted the event and again supported us tremendously during its organisation. Last but not least, SGAC would like to extend a thank you to all of the event's sponsors who helped make the Fusion Forum a reality. We are proud of the outcome of the sixth Space Generation Fusion Forum and look forward to building on its success and momentum.

Ali Nasseri
SGAC Chair

Stephanie Wan
Former SGAC Chair

Letter from Fusion Forum Managers

The aerospace industry is increasingly diverse across the globe, and this year's sixth annual Space Generation Fusion Forum brought together today's aerospace leaders with those of tomorrow, and captured the new ideas in these innovative times. The international organising team, consisting of 12 volunteers, selected representatives from government, military, industry, and academia to talk about the growth of new ideas and applications in the space sector. The event was a terrific success and a significant testament to the capabilities and passion of the organising team, Fusion Forum delegates, moderators, and speakers. Covering the topics of human spaceflight, space assets for Earth, scientific exploration, national security, and the New Space economy, we learned lessons from some of the most distinguished and successful members of the aerospace community and gained insight into the thinking of future leaders in the field from all corners of the world. Thanks to our sponsors and the participants, this event further solidified the Fusion Forum as a premiere event for the aerospace community. This report explains the details of the 2017 Space Generation Fusion Forum. We are already looking forward to next year's Forum.

Alexander Gibson
Space Generation Fusion Forum 2017 Manager

Minoo Rathnasabapathy
Space Generation Advisory Council Executive Director

**Theme of the sixth Space Generation Fusion Forum**

**The Evolving Space Frontier**

The New Space frontier is not simply the purely physical one to be pioneered by human and robot explorers, but also the current edges of law, policy, and regulation that must be pushed back to enable this development. Now more than ever, this frontier is rapidly evolving - and we must foster the spirit of adaptability across all disciplines to meet these challenges.

The 6th Space Generation Fusion Forum will explore this as a full spectrum approach to discuss the legal, policy, technology, and scientific aspects of the global space sector, as well as the innovation of new ideas for commercial ventures in the space startups arena.

SGFF 2017 will celebrate the discovery of new ideas and inspire the next generation to continue to be explorers in every aspect as they prepare to become the pioneers of the exciting and evolving frontiers of space.

**Inspiration and Context**

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The year 2017 has two special anniversaries: on 4th October 1957 Sputnik 1 became the first satellite to be launched into orbit. Just over a decade later, the Outer Space Treaty would come into effect on 10th October 1967. This marks the 60th anniversary of the launch of the first satellite into space, as well as the 50th anniversary of the Outer Space Treaty, the framework for all space law and policy today.

In the past 50 and 60 years, the space sector has evolved rapidly. We have gone from a single satellite emitting a beacon back to Earth, to having over 1,200 functional satellites currently in orbit assisting us with everyday life and monitoring of our planet. Space technology has evolved and created spin-off technologies which have impacted everything from how we communicate to the way surgeries are carried out. We have gone from the very first treaties on how nations access space, to now exploring the legal and ethical implications of asteroid mining and Mars colonisation by government and private entities.

It is a very exciting time to be a part of the space industry during such a pivotal period in its evolution, and we are pleased to celebrate these milestones during the 2017 Space Generation Fusion Forum.

**Space Generation Fusion Forum Overview**

The sixth annual Space Generation Fusion Forum was held 2nd and 3rd April 2017 at the Broadmoor Hotel, in Colorado Springs, Colorado, USA. Hosted by the Space Foundation in conjunction with the 33rd Space Symposium, SGFF 2017 brought together top students and young professionals from around the globe to discuss issues facing today's global space industry. Nearly all of the Fusion Forum delegates attended the 33rd Space Symposium, an event which welcomed over 11,000 international space professionals. The Fusion Forum began with opening introductions from SGAC Leadership, a keynote address by Mr. Steve Eisenhart of the Space Foundation and icebreaker introduction groups for the delegates. This was followed by two important keynotes from Dr. Johann-Dietrich Woerner, Director General of the European Space Agency (ESA), and Congressman Jim Bridenstine, author of the Space Renaissance Act. Selected delegates then presented short two to five minute lightning talks to highlight their impact on the space sector. Over lunch, the keynote speaker, Dr. Ben Clark (Lockheed Martin), discussed the history of Mars missions and his vision for future exploration of the red planet.

In the afternoon, delegates split into their discussion groups to address the topics of Human Spaceflight, Science and Exploration, The New Space Economy, Space for Earth, and Security and Sustainability as part of the focused interactive discussion sessions. Each section was moderated by a leader in the industry: Dr. Michael Hawes (Lockheed Martin), Dr. Jonathan Arenberg (Northrop Grumman), Mr Andrew Rush (Made In Space), Mr Carlo des Dorides (GSA), and Mr Phil Larson (University of Colorado Boulder), respectively. The final presentation of the day came from former Astronaut Colonel Paul Lockhart (USAF), who spoke of the important life lessons he had learned throughout his career. Following this, the delegates attended the Space Foundation's Yuri's Night celebration, enjoying the diverse entertainment with other space enthusiasts.

The second day of the Fusion Forum opened with a presentation from the President of the Canadian Space Agency (CSA), Sylvain LaPorte. This was followed by a keynote from Dr Michael Simpson from the Secure World Foundation (SWF), giving his vision for the future of international space cooperation and how the SWF's *Handbook for New Actors in Space* can assist. The delegates returned to their initial icebreaker groups and discussed where they saw the space sector going in the next five, 25, and 125 years.

Following the conclusion of the Space Generation Fusion Forum, the delegates were shuttled to the Broadmoor Hotel for the opening event of the Space Symposium's New Generation (NewGen) track—a luncheon with speed mentoring with influential members of the space community followed by a networking reception. The delegates then continued to enjoy the opening ceremonies of the 33rd Space Symposium alongside senior industry leaders and global representatives of the space community.

**Speakers and Moderators**

Jonathan Arenberg
*Chief Engineer, James Webb Space Telescope*
*Northrop Grumman*

Jonathan Arenberg has been with Northrop Grumman Aerospace Systems since 1989, starting his career with Hughes Aircraft Company in 1982. His experience includes optical, space and laser systems, along with work on the Chandra X-ray Observatory, James Webb Space Telescope, and is developing the Starshade concept for the direct imaging of extrasolar planets, which he co invented. He has worked on major high-energy and tactical laser systems, laser component engineering, metrology, and optical inspection issues. He is a member of the US National and International (ISO) subcommittees charged with writing standards for laser and electro-optic systems and components, International Society For Optics And Photonics (SPIE), American Astronomical Society, American Association for the Advancement of Science, American Institute for Aeronautics and Astronautics (AIAA), and Sigma Xi. Dr. Arenberg he holds a BS in physics and an MS and PhD in engineering, all from the University of California, Los Angeles. He is the author of over 140 conference presentations, papers and book chapters and holds numerous Patents in a wide variety of technological areas. Dr. Arenberg is currently the Chief Engineer for the James Webb Space Telescope and Space Science Missions at Northrop Grumman and an SPIE Fellow.

Representative Jim Bridenstine
*Oklahoma's First Congressional District*

Congressman Jim Bridenstine was elected in 2012 to represent Oklahoma's First Congressional District. He serves on the House Armed Services Committee and the Science, Space and Technology Committee. Bridenstine began his Naval career flying combat missions in Iraq and Afghanistan, gathering most of his 1,900 flight hours on an E-2C Hawkeye. He then transitioned to the F-18 Hornet and flew at the Naval Strike and Air Warfare Center, the parent command to TOPGUN. Along with nine years of active duty in the US Navy, Bridenstine's background includes a triple major at Rice University, an MBA from Cornell University, and business experience in real estate, ranching, aerospace, and defense contracting. After leaving active duty, Bridenstine returned to Tulsa to be the Executive Director of the Tulsa Air and Space Museum & Planetarium. Bridenstine was promoted to Lieutenant Commander in the US Navy Reserve in 2012. Most recently he transitioned to the 137th Air Refueling Wing of the Oklahoma Air National Guard, where he flies with an MC-12 squadron. In April 2016, at the 32nd Annual Space Symposium, Bridenstine introduced H.R. 4945, the American Space Renaissance Act, comprehensive reform legislation with provisions affecting national security, civil, and commercial space policy.

Dr Benton C Clark
*Co Investigator, Geochemistry, Planetary Protection, Lockheed Martin*

Dr. Benton C. Clark is Chief Scientist, Flight Systems, at Lockheed Martin Astronautics. He received his PhD in Biophysics from Columbia University in 1968. He was responsible for conceiving and developing the x-ray fluorescence spectrometers used for geochemical analyses of Martian soil samples onboard the Viking landers. He was Co-I for development of the lightflash detector and sunshade for the Particle Impact Analyzer (PIA) experiment, flown successfully on the Giotto mission. He has introduced the concept of key roles for cometary particulates and formation of comet ponds as an enabling step for the abiotic origin of life. He chairs the External Advisory Committee for the NASA Center for Research and Training in Exobiology at the University of California San Diego and Salk Institute. He has received the NASA Public Service Medal, the Wright Brothers Award, the Air Force Service Medal, and has been selected Inventor of the Year for Martin Marietta Corporation, and Author of the Year for Martin Marietta Astronautics.

Ariane Cornell
*North American sales for New Glenn, Business Development and Strategy Team for Blue Origin*

Ariane Cornell works on the Business Development and Strategy team for Blue Origin, LLC. She leads North American sales for New Glenn and astronaut portfolio. Ariane was formerly based in Vienna, Austria as the Executive Director of SGAC. She headed SGAC's delegations to international conferences and the United Nations (UN), and ran the organisation's operations, business development, strategy, and policy output. She has also served on the board of Women in Aerospace Europe, has guest blogged for Space News, and has sat on several committees of the International Astronautical Federation (IAF) and the American Institute of Aeronautics and Astronautics (AIAA). Previously, Ariane worked in international management consulting: first with Accenture based in San Francisco working on IT projects in the Philippines, South Africa, Brazil, and the US. Later with Booz Allen Hamilton in Washington, DC, where she helped develop strategies and solve operational issues for the world's top aerospace and defense companies. Ariane earned an MBA from Harvard University and a Bachelor of Science degree with honours in science, technology, and society with a focus in management science and engineering from Stanford University.

Dr Mary Lynne Dittmar

*Executive Director, Coalition for Deep Space Exploration*

Dr. Mary Lynne Dittmar is Executive Director of the Coalition for Deep Space Exploration, which grew from five companies to more than 60 under her leadership.Earlier in her career Mary Lynne worked for The Boeing Company, where she coordinated technology development of projects destined for the International Space Station. Later, she acted as a special advisor to the NASA Astronaut Office before her appointment as Boeing's first Chief Scientist for Commercial Utilisation of the International Space Station (ISS). Mary Lynne left Boeing in 2004 to start her own engineering and consulting firm. More recently she served as the Senior Policy Advisor for the Center for the Advancement of Science in Space (CASIS). She then became Executive Director for the Coalition in late 2015. Dr. Dittmar is a fellow of the National Research Society, an Associate Fellow of the AIAA, and is a member of the Board of Directors of the American Astronautical Society. From 2012-2014, she served as a member of the National Research Council Committee on Human Spaceflight and is beginning her second term as a member of the Executive Committee of the Space Studies Board of the National Academies of Sciences, Engineering, and Medicine.

Pierre Delsaux
*Deputy Director General, European Commission*

Pierre Delsaux is Deputy Director General at the European Commission Directorate General for the Internal Market, Industry, Entrepreneurship and SMEs. After studying Law at the University of Liège, he obtained his Master of Law at the Northwestern University, Chicago. He was Legal Secretary at the European Court of Justice from 1984 to 1987. Delsaux worked in the private sector before joining the European Commission in 1991. He started his career within the European Commission in the Directorate General for Competition. He was appointed director and became responsible for regulating the financial services in 2007. Following this, he was appointed Deputy Director General with responsibilities for the Single Market in the EU. Since December 2015, he has been in charge of Space Policy and Defence.

Carlo des Dorides
*Executive Director of the European Global Navigation Satellite Systems Agency (GSA)*

Mr. des Dorides sets the vision of the GSA and ensures that it is well placed to support the effective operation, maintenance, and security of Europe's satellite navigation systems. Mr. des Dorides has decades of experience managing space service teams. Most recently he had key management responsibilities at the European Commission and was responsible for the definition of the Galileo/EGNOS, the European Geostationary Navigation Overlay System, exploitation and operational phase. Before joining the Commission, Mr. des Dorides led the Concession Department at the European Global Navigation Satellite System (GNSS) Supervisory Authority and served as Chief Negotiator of the Galileo Public-Private-Partnership/Concession contract at the Galileo Joint Undertaking. As Director of Programmes and Engineering at ENAV, the Italian air navigation service provider, he was responsible for updating the technology of Italian airports and Area Control Centres. Prior to that, he held several management positions in the aerospace private sector

including Head of advanced telecommunication programmes and Program Manager for major satellite telecommunication projects. Mr. des Dorides holds a degree in engineering from the University of Rome and an MBA. from CUOA, Vicenza, Italy, complemented by his studies at the International Space University (ISU) in Toulouse.

W. Michael Hawes, D.Sc.
*Vice President and Orion Program Manager*
*Lockheed Martin Space Systems Company*

W. Michael Hawes, DSc, is the Vice President and Orion Program Manager for Lockheed Martin Space Systems Company. Dr. Hawes joined Lockheed Martin in July 2011 after concluding a 33-year career with the National Aeronautics and Space Administration (NASA), and was selected to head up Lockheed Martin's Orion Program Office in 2014. Prior to joining the Orion Program, he served as the Director for Human Spaceflight Programmes with Lockheed Martin. In this role, he was responsible for representing the Human Spaceflight/Space Systems Company organization with the Administration and Congress. Dr. Hawes has a diverse background of programme management, aerospace engineering, mission operations, and leadership experience. During his career with NASA, Dr. Hawes served as the Associate Administrator for Independent Program and Cost Evaluation (IPCE) where he was responsible for providing objective studies and analyses in support of policy, programme, and budget decisions by the NASA Administrator. He also served as the Deputy Associate Administrator for Program Integration in the Office of Space Operations at NASA Headquarters, and supported the Space Shuttle Program's Return to Flight actions as well as the transition and disposition of Space Shuttle assets following the programme's conclusion.

Steve Eisenhart
*The Space Foundation Senior VP for Strategic and International Affairs*
As head of international affairs, Eisenhart is principally responsible for the Space Foundation's global strategy and relationships with international space agencies and organisations, foreign embassies and US organisations involved with global space programmes. He is directly responsible for the programme development and integration of key Space Foundation activities including the annual Space Symposium. He also supervises the Space Foundation's government affairs activities in the Washington, DC, office including relationships with government agencies, other space advocacy organisations and associations and corporate interests. Since joining the Space Foundation in 1996, Eisenhart has held a broad range of responsibilities, serving as senior vice president of strategic communications, director of communications and public affairs and communications manager. Eisenhart was a military public affairs official and is a graduate of the United States Military Academy at West Point.

Sylvain Laporte

*President, Canadian Space Agency*

Before being appointed as President of the Canadian Space Agency,

Sylvain Laporte was the Chief Executive Officer of the Canadian Intellectual Property Office (CIPO). CIPO is a federal organisation responsible for administering the Patent Act and managing requests related to trademarks, copyright, industrial design protection and patents. As CEO of CIPO, Mr. Laporte was also Commissioner of Patents and Registrar of Trademarks. Previously, he held the position of Executive Director, Industrial Technologies Office (ITO) at Industry Canada, where he was responsible for managing financial contribution programmes in research and development for the aerospace, defence, security and space industries. Before joining the public service, he worked for the Canada Post Corporation in various sectors, such as marketing, retail, logistics and information technology. Laporte gained extensive experience as an aerospace engineer over the course of his 20-year career with the Canadian Armed Forces. He held various positions in such fields as engineering, maintenance, and human resource management. He earned a bachelor's degree in computer science from the Collège militaire royal de Saint-Jean, and a master's degree in computer engineering from the Royal Military College in Kingston.

Phil Larson

*Assistant Dean, University of Colorado Boulder*

Phil Larson currently serves as the assistant dean for communications, strategy, and planning. He leads strategic relations for the College of Engineering and Applied Science at the University of Colorado – Boulder. Larson was senior advisor for space and innovation at the White House, where he served from 2009 to 2014. Most recently, Larson was part of Elon Musk's SpaceX team, supporting communications efforts as well as managing corporate projects. During his time at the White House, Larson worked closely with Dr. John P. Holdren, President Obama's science and technology advisor, on the nation's science, technology and innovation priorities. Larson coordinated strategic communications across multiple federal agencies, including the Environmental Protection Agency, Federal Aviation Administration, NASA, National Institutes of Health, National Science Foundation, and Departments of Commerce, Defense, Education, and Energy. He also spent time in the White House Office of Management and Budget helping to craft NASA's budget and policy priorities. At SpaceX, Larson was part of the company's strategic communications efforts and led the overall digital strategy. Larson is a member of Embry-Riddle Aeronautical University's Commercial Space Operations advisory board, as well as the Science and Entertainment Exchange at the National Academy of Sciences. He received a bachelor of science degree in aerospace studies, with minors in space studies, psychology, human factors and communications, from Embry-Riddle. He completed graduate coursework in science and technology policy from The George Washington University before taking a job in the White House Office of Science and Technology Policy in 2009.

Col Paul Lockhart

*United States Air Force (USAF) (Retired)*

Lockhart received a Bachelor of Arts degree in Mathematics from Texas Tech University in 1978, and a Master of Science degree in Aerospace Engineering from University of Texas at Austin before being commissioned in 1981 into the USAF. He is also a distinguished graduate of both Reserve Officers Training Corps (ROTC) and the Air Force Squadron Officer School. Lockhart was assigned to the 49th Fighter Interceptor Squadron flying T-33s. In 1986, he transitioned to the F-4 and flew operationally with US Air Forces. In 1991 he reported to Edwards Air Force Base, California,

for yearlong training as a test pilot in high performance military aircraft. Upon graduation, he was assigned to the Test Wing at the Air Force Developmental Test Center at Eglin Air Force Base, Florida, performing weapons testing for the F-16 aircraft. During his four and a half year tour at Eglin, he was selected as the Operations Officer for the 39th Flight Test Squadron. Much of America's state-of-the-art weaponry was first tested under his guidance at the 39th Flight Test Squadron. He has logged over 5,000 flying hours in more than 30 different aircraft and the Space Shuttle. Lockhart was selected as an astronaut candidate in 1996. Lockhart's two space missions, STS-111 and STS-113, both in 2002, were missions to the International Space Station. After his service with NASA, Lockhart was assigned to and graduated in 2004 from the Royal College of Defence Studies in London, United Kingdom. His last military assignment was with the headquarters Air Force, A9, where he was a directorate chief for both the force structures and the analyses and assessments branch. Lockhart retired from the USAF in January 2007 and returned to NASA in an administrative position.

Andrew Rush
*President, Made In Space*

As president of Made In Space, Inc., Andrew oversees the operations, business development, and strategy of Made In Space as it continues to push boundaries at the forefront of in-space manufacturing, 3D printing in space, at sea, in other extreme environments, and space colonisation-related technologies. Previously, Andrew was an intellectual property attorney. He was one of the few intellectual property lawyers nationally with established industry specialisations in aerospace and additive manufacturing. While in private practice, he was named partner before the age of 30 and became involved with Made In Space as General Counsel and manager of the company's intellectual property portfolio. Before becoming an attorney, he was a research assistant in a solid state physics laboratory and worked at Masten Space Systems.

Michael Simpson
*Director for Space Strategy and Plans in the Office of the Under Secretary of Defense for Policy in the US*

Dr. Michael K. Simpson is the Executive Director of Secure World Foundation (SWF). Dr. Simpson joined SWF as the Senior Program Officer in September 2011 following seven and a half years as President of the International Space University. Dr. Simpson holds a post as Professor of Space Policy and International Law at ISU. He is a member of the International Academy of Astronautics and the International Institute of Space Law and is a Senior Fellow of the International Institute of Space Commerce. After 23 years of service, Dr. Simpson retired from the Naval Reserve in 1993 with the rank of Commander. Dr. Simpson's practical experience includes service as a Political Military Action Officer, observer representative to the UN Committee on the Peaceful Uses of Outer Space, participating organisation representative to the Group on Earth Observations (GEO) and member of the Association of Space Explorers International Panel on Asteroid Threat Mitigation. He currently serves on the Commercial Spaceflight Safety and Space Security Committees of the International Astronautical Federation (IAF) and is a Vice Chair of the Hague Space

Resources Governance Working Group. He sits on the governing board of the World Space Week Association (WSW), and is a governor of the National Space Society in the United States. Dr. Simpson is the author of numerous scholarly papers, presentations, articles and book contributions.

Johann-Dietrich Woerner
*ESA Director General*
Johann -Dietrich 'Jan' Woerner became the ESA Director General on 1 July 2015. Previously, from March 2007 to June 2015, he served as Chairman of the Executive Board of the German Aerospace Center (DLR).
Jan Woerner was born in Kassel, Germany, in 1954. He studied civil engineering at the Technical University (TU) Berlin and TU Darmstadt, from where he graduated in 1985. In 1982, as part of his studies, he spent one year in Japan, investigating earthquake safety of nuclear power plants. Until 1990, Mr Woerner worked for consulting civil engineers Koenig und Heunisch. In 1990 he returned to TU Darmstadt, where he was appointed as a professor of Civil Engineering and took over as Head of the Test and Research Institute. Before being elected as President of TU Darmstadt in 1995, he held the position of Dean of the newly established Civil Engineering Faculty. Jan Woerner headed the university from 1995 to 2007 and succeeded in making it the first autonomous university of the Federal Republic of Germany. Jan Woerner has been awarded numerous prizes and positions, such as the Prize of the Organisation of Friends of Technical University Darmstadt for 'outstanding scientific performance'. He was also appointed to the Berlin Brandenburg Academy of Sciences and to the Convention for Technical Sciences (acatech) and is a representative of the Technical Sciences Section of the Leopoldina, the national academy of sciences of Germany. Jan Woerner has received honourary doctorates from New York State University at Buffalo (USA), technical universities of Bucharest (Romania) and Mongolia, the Saint Petersburg University for Economics and Finance (Russia) and École Centrale de Lyon (France). He has received the Federal Cross of Merit (Officer's cross, 1st class) of the Federal Republic of Germany for his continuous efforts regarding the next generation of scientists and Germany as a location for Science, Technology and Engineering. He has furthermore been awarded the honours of Knight of the French Légion d'Honneur. Jan Woerner was Vice President of the Helmholtz Association and also a member of various national and international supervisory bodies, advisory councils and committees. He was a member of the administrative boards of École Centrale Paris, École Centrale de Lyon, TU Berlin, the Instituto Superior Técnico, University of Lisbon, the Arts and Music University in Frankfurt and has been a member of a number of supervisory boards including Carl Schenck AG, Röhm GmbH, TÜV Rheinland AG and Bilfinger SE. Furthermore, he was appointed to the energy expert group of the German Government. Before joining ESA as Director General, Jan Woerner was head of the German delegation to ESA from 2007 to 2015 and served as Chairman of the ESA Council from 2012 to 2014.

**Space Generation Fusion Forum Highlights**

**Day 1: Space Generation Fusion Forum 2017 Brings Space Leaders Together From around the World**

The delegates arrived Sunday morning at the Broadmoor Hotel's Cheyenne Lodge, Colorado Springs. With help from Space Foundation, and held in conjunction with the 33rd National Space Symposium, the Space Generation Fusion Forum brought together young professionals from government, industry, and

academia from around the globe to discuss space today and how the industry will look in the future.

This year's theme The Evolving Space Frontier, was introduced by SGFF Manager Alexander Gibson, while reflecting on his first SGFF in 2014 and the impact it had made on him personally and professionally. SGAC Executive Director, Minoo Rathnasabapathy, welcomed delegates from 18 different countries and introduced Steve Eisenhart, Senior VP of Strategic and International Affairs for Fusion Forum.

Steve shared three major tips for this year's delegates:

1. Be proud to be selected.
2. Be proud to be a space person.
3. Have fun!

On that note, the delegates broke into smaller groups for an icebreaker activity where they introduced themselves, briefly explaining their background and what they hoped to glean from their time at SGFF.


*Steve Eisenhart, Vice President of Strategic and International Affairs at Space Foundation, opens SGFF 2017 with a keynote*

After everyone broke for a quick coffee break, SGAC Co-chair Ali Nasseri introduced the first keynote speaker of the day, Jan Woerner, ESA Director General. Mr. Woerner discussed not only what goals ESA has, but how the member states work together to pick and prioritise those goals. He also highlighted the differences in culture between ESA and NASA, culminating in a humorous video compilation highlighting the different ways each agency celebrated Philae and Curiosity successfully reaching their

destinations.

The next keynote speaker of the day was Rep. James Bridenstein from Oklahoma's First District. He highlighted the current gap between space technology and space policy. He also commented on the delicate balance that must be maintained between the commercial sector and governments to leverage space technologies to benefit society and encourage commercial development.


*Congressman Jim Bridenstine, Oklahoma's First District, talking to the attendees*

Next, eight of this year's delegates were highlighted in the Ignite Talks, with each bringing a different topic and a unique perspective on the future of the Space Industry. Soon it was time for the luncheon graciously sponsored by Lockheed Martin. Retired Lockheed Martin Engineer Dr. Ben Clark shared not only his wealth of knowledge following decades of work on nearly every Martian mission, but what he saw as the challenges and possibilities of manned Mars missions in the future.

That very memorable keynote was followed by the introduction of and short discussion with each of the discussion track moderators. This year SGFF had five discussion tracks, with the following moderators:

1. Investing in Space/The New Space Economy – Andrew Rush, President, Made in Space
2. Space Sustainability, and Security – Phil Larson, Associate Dean of the College of Engineering and Applied Sciences, University of Colorado, Boulder
3. Human Spaceflight – Dr. Michael Hawes, VP & Orion Program Manager, Lockheed Martin
4. Science and Exploration – Dr. Jon Arenberg, Northrop Grumman
5. Space for Earth – Carlo des Dorides, Executive Director, GSA


*Discussion Group Moderators (from left): Andrew Rush (Made in Space), Dr Jon Arenberg (Northrop Grumman), Dr. Mike Hawes (Lockheed Martin Space Systems Company), Ali Nasseri (SGAC Chair), Stephanie Wan (outgoing SGAC Chair), Carlo des Dorides (European GSA), Minoo Rathnasabapathy (SGAC Executive Director), Alexander Gibson (SGFF 2017 Manager), Phil Larson (University of Colorado Boulder)*

Once the discussion groups were over, Carlo des Dorides, Executive Direction of GSA, gave a keynote speech about the opportunities afforded by the new Galileo satellite constellation and other topics such as the role of big data in space applications.

Following his keynote, one representative was chosen from each of the discussion groups to present the key highlights of what was discussed to the rest of the Space Generation Fusion Forum delegates.

*Delegate panel (from left): Brandon Seifart (USA), Minoo Rathnasabapathy (SGAC Executive Director), Oniosun Temidayo Isaiah (Nigeria), Jillian Yuricich (USA), Jan Lukačevič (Czech Republic NPoC), Alexander Gibson (SGFF 2017 Manager), Lauren Smith (USA NPoC), Ali Nasseri (SGAC Chair)*

The closing keynote speaker was former Astronaut Col. Paul Lockhart who provided some inspiring life lessons learnt over his long career and encouraged the delegates to be bold and go after their goals seeking mentorships along the way. At the end of the day, delegates reunited to celebrate Yuri's Night.

**Day 2: Space Generation Fusion Forum Participants Conclude Event with New Friends, New Knowledge, and New Perspectives**

After a successful first day, delegates returned to the Broadmoor Hotel's Cheyenne Lodge for a second day of lovely weather and a lineup of great speakers to complete the 6th Annual Space Generation Fusion Forum.

In celebration of Canada's 150 years of Confederation, Canadian Space Agency (CSA) President Sylvain Laporte was greeted by delegates waving the Canadian flag as he approached the podium to give the opening keynote speech of the day. He detailed the role of the CSA in current spaceflight operations, adding some entertaining stories and videos of astronauts in training. He explained that innovation and leverage of social media will be a key focus of the CSA going forward.

The delegates were provided with three special cupcakes in celebration of the Canadian Confederation and the anniversaries of both the Sputnik launch and the signing of the Outer Space Treaty.

Dr. Michael Simpson, Executive Director of the Secure World Foundation was the next keynote speaker

highlighting the importance of cooperation in space, referencing the UNISPACE+50 as a prime example. Dr. Mary Lynne Dittmar, from Coalition for Deep Space Exploration, and Ariane Cornell, from Blue Origin, took the stage as our experts on launch. Each explained differences of commercial and government approaches to launch vehicles and how there should not be an us vs. them mentality as vehicle builds will vary in order to be the right tool for the job.

The delegates then broke into the groups to discuss how they saw the future of space in the next five, 25 and 125 years, brainstorming milestones and achievements that would allow the space industry to reach those milestones.

The closing keynote speaker for the SGFF was EU Commission Deputy Director General, Pierre Delsaux, who encouraged the delegates to reach out to people outside the space industry. He explained that there are millions of people who may not have the same passion for space because no one has taken the time to explain to them why it is important and how that is the real challenge.

To finish the sixth SGFF, SGAC Co Chair, Ali Nasseri, gave a short presentation on upcoming events and other ways the delegates could be involved in the organisation. SGFF Manager, Alexander Gibson, closed the Forum by announcing the 2018 Manager, Chantelle Dubois. He did so by using the analogy of the team being like a starship crew to highlight her contributions as the 2017 Deputy Manager/First Officer and conveying how exciting it will be see her captain the next SGFF.

SGAC is very thrilled with the connections made and conversations had at this year's Fusion Forum. The event would not have been possible without the generous time and insight donated by industry leaders who participated as speakers and mentors, the delegates who committed to participating fully throughout the event, and the Space Foundation who provided support and encouragement. Finally, SGAC would like to thank the 2017 Fusion Forum sponsors: Space Foundation, Lockheed Martin, GSA, Ball Aerospace, Secure World Foundation, AGI, Overlook, and Northrop Grumman.

**Space Generation Fusion Forum Participation in 33rd Space Symposium**

After the Space Generation Fusion Forum, a number of SGFF delegates remained for the rest of the week for the 33rd Space Symposium. This week-long event brings together space leaders from around the world to discuss, address, and plan for the future of space. The New Generation track was an integrated part of the Symposium that allowed SGFF delegates to actively contribute to discussions.

The New Generation Track began with a welcome lunch and speed mentoring. Attendees joined small group discussions with a range of industry leaders who talked about their experiences of navigating the industry and shared invaluable advice. Other highlights of the week included a night of astrophotography with Buzz Aldrin, a day dedicated to discussions about Mars, and a New Gen breakfast where The Space Report presented career prospects and opportunities for young space professionals.

SGAC members moderated the multiple days of the event whilst SGFF delegates were able to attend talks and explore the vast exhibition hall. On the final day, SGAC Executive Director Minoo Rathnasabapathy, together with SGFF 2017 manager Alex Gibson, summarised the successes of the SGFF. The week concluded with a reception in honour of New Generation Space Leaders.

**Space Generation Fusion Forum Statistics**

Over 70 students and young professionals from 11 countries participated in the sixth Space Generation Fusion Forum, along with nearly 20 keynote speakers, Discussion Track moderators, and industry professional mentors who attended as guests. The 2017 Space Generation Fusion Forum had the highest

number of applicants to date, with 147 applications to attend the programme. Four delegates were selected from a competitive pool of 70 applicants to receive Global Grant scholarships to attend the Space Generation Fusion Forum, helping broaden SGAC's international network and allowing delegates to interact with people from a variety of backgrounds. These delegates hailed from Australia, Mexico, the United Kingdom, and Nigeria. Of the 60 delegates, 40% were female and 60% male. The young professional attendees came from a variety of space-related fields, including aerospace medicine, space law, space policy, operations, engineering and science. Delegates represented commercial and military organisations, space agencies, and universities from 14 different countries.

**Space Generation Fusion Forum 2017 Global Grant Winners**

**Danton Bazaldua (Mexico)**

Danton Bazaldua is studying Telecommunication Engineering at the National University Autonomous of Mexico with a focus on Satellite Communication Networks. Danton has collaborated with the Institute of Nuclear Science (UNAM) developing laser communication systems and testing of satellite communications in space. Danton's first involvement with SGAC was as part of the Local Organizing Committee for the Space Generation Congress 2016 that was held in Guadalajara, Mexico. Moreover, he was coordinator of the Poland Mars Analogue Simulation Workshop and is actively involved with the Space Exploration Project Group (SEPG). Danton is also an active member of the Law and Space Policy Group that collaborates with the Latin America and the Caribbean (GRULAC) which focuses on Space Economics and Benefits for Latin America. At the beginning of 2016 Danton won the first place in the Mexican Design Mission Contest hosted by the University of Surrey. During the International Astronautical Congress 2016, he had the opportunity to present articles about satellite communications and space economy in Latin America.

**Harriet Brettle (United Kingdom)**

Harriet Brettle is Outreach Coordinator for the Planetary Society in London and is working to strengthen the organisation's presence in the UK. She is currently studying astrophysics at Queen Mary, University of London and researching methods to improve exoplanet detection. Harriet volunteers with SGAC as executive co-secretary and is a member of the Space Law and Policy project group. She has a keen interest in improving public engagement with space science, interactions between different fields relevant to space exploration, and the future of space financing. Harriet also has a mathematics degree from the University of Warwick.

**Oniosun Temidayo Isaiah (Nigeria)**

Oniosun Temidayo Isaiah is a graduate of Meteorology from the Federal University of Technology, Akure, Nigeria, and the Pioneer President of the University Space Club. He is a former Intern at the National Space Research and Development Agency, a member of the SGAC web team, 2016 Recipient of the IAF Emerging Space Leaders Grant, Nigeria Chapter lead for Lunar Mission One, Global Youth Mapper Leader, and a campus representative of University Space Engineering Consortium (UNISEC). Temidayo currently works with the Centre for Space Research and Applications, Federal University of Technology Akure, where he is instrumental to the ground station development of Nigeria EduSat-1, a collaborative project between the University Centre for Space Research and Applications, Centre for Satellite Development of National Space Research and Development Agency, and Kyushu Institute of Technology, Japan.

**Jessica Todd (Australia)**

Jessica Todd has just completed her Bachelor of Aerospace Engineering and Bachelor of Advanced Science at the University Sydney. She is an alumni of the ISU's Southern Hemisphere Space Studies Program (SH-SSP) and will be pursuing a Masters of Aerospace Engineering in the United States starting in August 2017. Jessica has been a member of SGAC for the last five years, working as part of the PR and Communications team, and as the PR and Communications Coordinator for SGC 2015. Throughout her academic career Jessica has been involved in a number of space projects, including the development of a Martian aerostat for low-altitude imaging, and a Virtual Reality Mars Simulator to simulate spacecraft subsystem integration. In 2015 she worked at the Australian Astronomical Observatory, developing the data pipeline for a new ground based multi-lens telescope, and she has recently completed an internship at the Space Environment Research Centre, helping to track conjunctions of GEO satellites. Jessica has a driving passion for all things space, with a keen interest in the field of robotics and bioastronautics, and hopes to study the cooperation of human and machine systems for future space missions.

## Schedule

SPACE GENERATION ADVISORY COUNCIL | SPACE GENERATION FUSION FORUM 2017

**Colorado Springs – USA, 2-3 April 2017**

**All events held in the Cheyenne Lodge of the Broadmoor Hotel unless otherwise noted*
*** This schedule is tentative and subject to change - last updated April 1st, 2017*

| | | |
|---|---|---|
| **Sunday, April 2nd** | | |
| 08:00-09:00 | **Delegate Registration** (Cheyenne Lodge) | **Shuttle Transport From Hotel Elegante to Cheyenne Lodge** (Delegates to meet in lobby of hotel at 8:00 am) |
| 09:00-09:15 | **Opening Remarks** | |
| 09:15-09:30 | **Opening Keynote** Steve Eisenhart, Senior Vice President - Strategic & International Affairs, Space Foundation | |
| 09:30-10:00 | **Group Introduction and Ice Breaker Activity** | |
| 10:00-10:15 | **Coffee Break** | |
| 10:15-10:35 | **Keynote** Dr. Jan Wörner, Director General, European Space Agency | |
| 10:40-11:00 | **Keynote** James Bridenstine, Congressman, Oklahoma's First District (American Space Renaissance Act) | |
| 11:00-12:00 | **Interactive Session** Ignite Talks | |
| 12:00-13:00 | **Luncheon and Keynote** Dr. Ben Clark, Lockheed Martin Space Systems Company | |
| 13:00-13:35 | **Interactive Session** Discussion Tracks: Speaker Introductions | |
| 13:35-14:45 | **Interactive Session** Discussion Tracks: Round Table | |
| 14:45-15:15 | **S'mores Break** | |
| 15:15-15:35 | **Keynote** Carlo des Dorides, Executive Director, European GNSS Agency (GSA) | |
| 15:40-16:25 | **Interactive Session** Discussion Tracks: Delegate Panel | |
| 16:30-17:00 | **Closing Keynote** Col. Paul S. Lockhart, Former NASA Astronaut, USAF (Ret.) | |
| 17:00-17:30 | **Group Photo & Awards** | |
| 17:30-17:45 | **Shuttle Back to Hotel Elegante** | |
| 18:00-18:15 | **Shuttle Transport Yuri's Night** (Delegates meet in lobby of hotel) | |
| 18:15-21:00 | **Yuri's Night** (Space Foundation Discovery Center) | |
| 21:00-21:15 | **Shuttle Transport to Hotel Elegante** (Delegates meet in front of the Space Foundation Discovery Center) | |
| **Monday, April 3rd** | | |
| 08:00-08:30 | **Shuttle Transport From Hotel Elegante to Cheyenne Lodge** (Delegates meet in lobby of hotel) | |
| 08:30-08:45 | **Welcome** | |
| 8:45-09:15 | **Opening Keynote** Sylvain Laporte, President, Canadian Space Agency | |
| 09:15-10:00 | **Interactive Session** The Future of Launch: Panel & Debate | |
| 10:00-10:15 | **Keynote** Dr. Michael Simpson, Executive Director, Secure World Foundation | |
| 10:15-10:30 | **Coffee Break** | |
| 10:30-11:00 | **Closing Keynote** Elzbieta Bienkowska, Commissioner, EU Commission | |
| 11:00-11:30 | **Interactive Session** Milestone Projections | |
| 11:30-11:45 | **Closing Remarks** Minoo Rathnasabapathy (Executive Director, SGAC) & Alexander Gibson (Manager, 2017 SGFF) | |
| 11:45-12:00 | **Shuttle Transport to Broadmoor Hotel** 33rd Space Symposium NewGen Lunch, Opening Ceremonies | |

SPACE GENERATION ADVISORY COUNCIL | SPACE GENERATION FUSION FORUM 2017

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**Space Generation Fusion Forum Organising Team**

Alexander Gibson (USA), Space Generation Fusion Forum 2017 Manager
Minoo Rathnasabapathy (Australia/South Africa), Space Generation Advisory Council Executive Director
Chantelle Dubois (Canada), Space Generation Fusion Forum 2017 Deputy Manager
Jim Behmer (USA), Logistics Coordinator
Greg Bonn (USA), Logistics Coordinator
Michelle Knox (USA), PR and Communications Coordinator
Cody Knipfer (USA), PR and Communications Coordinator
Carolyn Belle (USA), Programmes Coordinator
Anja Peculjic (Serbia), Programmes Coordinator
Kristin Shahady (USA), Delegates Coordinator
Tasman Powis (Australia/UK), Delegates Coordinator
Daniel Brack (Israel/USA), Operational Support
Bradley Farquahar (Canada), Operational Support
Justin Kugler (USA), Operational Support

**Discussion Track Session Reports**

**Human Spaceflight**

2017 commenced with the loss of the last man to stand on the Moon, with no near-term plans for once again sending humans to other bodies of our solar system. Even as government and commercial players discuss the return of humans to the Moon, visitation of an asteroid, or exploration of Martian orbit, the debate regarding how to structure and fund human spaceflight continues. Should human exploration be preceded by robotic research? Do we have the necessary engineering and psychological know-how to sustain human life through long-duration space travel? Which destinations should be prioritised? What role does international collaboration play in human spaceflight efforts? This topic will explore the multifaceted nature of implementing human spaceflight, looking at proposed roadmaps and weighing the challenges facing this enduring aspiration.

Moderator: Dr. W. Michael Hawes (USA)
Rapporteurs: Kristin Shahady (USA), Jessica Todd (Australia)

Delegates:

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|---|---|
| Barret Schlegelmilch | USA |
| Chris Nie | USA |
| Jillian Yuricich | USA |
| Kavya Manyapu | USA |
| Scott Waters | USA |
| Vanessa Clark | Australia |
| Daniel Reynolds | USA |
| Eleanor Morgan | USA |
| KangSan (Antonio) Kim (Stark) | Republic of Korea |
| Jessica Todd | Australia |
| Saul Rexa Arcelus | Mexico |
| Anthony Yuen | Australia |

The goal for this discussion track was to address important questions and issues regarding the future of human space exploration and, in particular, deep space exploration. The Discussion Group was in agreement that human exploration of the solar system should continue in conjunction with robotic missions. While both Mars and the Moon (including cis-lunar missions) were discussed as the potential next step in human deep space exploration, the group was divided on which should be humanity's next goal. Much of the support for the Moon as the next crewed goal stemmed from the use of the celestial body as a logical test-bed for technologies needed for Mars. Missions to the Moon could allow us to solve many of the problems that need to be addressed to get us to Mars (closed-loop habitation, radiation shielding etc.) within a safe six day return trip to Earth. The Moon also offers the opportunity to establish a sustained human presence outside of low Earth orbit (LEO) and establish a space economy, before

venturing deeper into the Solar System.

On the other side of the argument, many in the group were of the opinion that the current Mars hype that permeates pop culture and the media should be capitalised on. There is a great deal of public interest in going to Mars, and by returning to the Moon we risk dead-ending on the Moon and losing public support, as was seen towards the end of the Apollo era. Aiming for Mars now keeps public support, and therefore political support, on our side. On the ethics of currently sending humans to Mars, no consensus in the group was reached. As stated above, there was considerable support for further testing of technologies before any manned mission to Mars is launched. There was also the argument that no matter how many simulations and tests are run, either on Earth, on the surface of the Moon, or in cis-lunar space, there will still be unforeseen circumstances and problems to be addressed in a Mars mission. Aiming for Mars immediately allows us to wholly devote our resources to that goal, rather than spending years or potentially decades on the Moon testing technologies.

The key issue brought up within the discussion was that future human space exploration would only continue and be successful if it is sustainable. This concept of sustainable exploration refers to three key issues: economic sustainability, technological sustainability, and sustained interest and support from the general public.

**Economic Sustainability**

As it currently stands, human space exploration is an expensive endeavour. There is relatively low demand for the technologies needed for such missions and thus costs are incredibly high. Establishing a space economy, and increasing demand for technologies means costs can be driven down (for example, the cost of launch vehicles is decreasing as the number of launches increase). Any sustained human presence in deep space will require sustained financial backing and a sustained space economy. Space tourism may be one way to address the issue of financial backing, using the revenue generated to fund exploration missions, as SpaceX proposes. However, the establishment of a self-sustaining economy would ensure that demand continues. This requires the expansion of industries that rely on either space resources, or space technologies. The establishment of a continuous human presence on the Moon could potentially foster this growth. Companies which establish themselves on the Moon could generate revenue from in-situ resources, whilst also requiring supplies from Earth, generating some sort of trade between the two.

**Technological Sustainability**

Technological sustainability refers to developing technologies that allow a sustained deep-space presence, such as closed-loop habitats and life support systems. Technologies used for future human missions also need to be able to provide benefits back on Earth, in keeping with developing a space economy and making such missions economically viable.

**Sustained Public/Media Interest**

Future human space missions are likely to be long-term, ranging from months to years, and thus it is crucial that public interest and political support for these missions is generated and sustained. Whilst we, as professionals of the industry, understand the benefits of human missions back on Earth, the general public often has a skewed concept of space exploration and views it as a luxury. Generally speaking, people do not want to hear about money being spent on issues that do not directly affect them. It is crucial that the achievements made in space exploration are promoted to the general public by demonstrating the trickle down effect of these achievements in their own lives. It is also important to remind the public that life as it currently stands is not sustainable on Earth. We cannot remain a one-planet species and thus exploration of the solar system is vital to our very survival.

An idea brought up in our discussion was to set milestones along the mission timeline, as a means of

sustaining public interest. When milestones are achieved the public is kept engaged and excited, and thus support for the missions continue. Mars as a goal for human exploration requires sustained public interest for the next 10-15 years minimum. In the era of 24-hour news cycles and social media, it is important that various platforms are used to promote these missions (for example, Curiosity having a Twitter account has been a very successful PR move by NASA).

The final point of our discussion was the issue of international collaboration for future human missions, or rather, international collaboration versus international competition. Sending humans into deep space has long been described as needing a global effort. Such collaboration fosters good political relationships between international partners and allows the development for such a mission to be divided over a number of countries. The International Space Station is a prime example. With a collaborative effort, however, comes various political issues and conflicting interests and navigating these problems can slow the development process. In contrast, competition between countries or private companies has driven faster innovative thinking and development, the space race of the 1960s being an excellent example. We debated whether global cooperation is actually a help or a hindrance to the process of sending humans to the Moon or Mars, and came to the conclusion that cooperation *with* competition is the best way forward. Cooperation between governments, or between a government and a private company allows us to better overcome the steep learning curve needed for the next stage of human space exploration. We were also in agreement that landing on the next planetary body should be a global effort, not just the work of one country. Generating competitions between contractors or private companies would be a good way to ensure fast and innovative development of technologies, as NASA is currently doing with their commercial crew and supply vehicles for the ISS. The government remains the customer, and is able to cooperate with other governments, and competition between the various private companies continues to drive innovation.

Overall, everyone in the discussion group reached the same conclusion. Regardless of whether we choose to return to the Moon or head to Mars, action is required. In the last 30+ years there has been too much talk about deep space human exploration and too little action. Humanity cannot remain a one-planet species, and the technologies developed for these missions will have numerous benefits for those of us back on Earth. The foundation has been laid for these missions and now a solid mandate and commitment from the various global and industry partners is needed.

**Science and Exploration**

A quest for knowledge and passion for exploration lies at the heart of humanity's earliest interactions with space. Yet even as space agencies and universities around the world pursue scientific objectives in space, questions remain as to how best to channel efforts and undertake scientific missions. How can we balance the cost and scientific output of missions: what is the relative value of more low cost missions compared to fewer high cost missions? Is there an expanded role for industry to play in science and exploration, beyond as the contractor for construction and launch? What efforts can be made to include more nations in scientific pursuits, particularly those that have an interest but not yet the budget or expertise to conduct solo missions? How can the public once again become engaged with space exploration?

Moderator: Dr. Jonathan Arenberg (USA)
Rapporteurs: Daniel Brack (USA), Danton Bazaldua (Mexico)

Delegates:

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|---|---|
| Owen Hart | USA |
| Ana Raposo | Portugal |

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|---|---|
| Jan Lukacevic | Czech Republic |
| Danton Bazaldua | Mexico |
| Patrick Harper | USA |
| Michael Kretzenbacher | Australia |
| Javier Stober | USA |
| Swetha Kotichintala | India |
| Alving Leung | USA |
| Marcia Fiamengo | USA |
| Ashley Morgan | USA |
| Tanya Harrison | Canada |

During the 2017 Space Generation Fusion Forum, the round of the Science and Exploration Discussion focused on answering the question about the sustainability of space science and the exploration of deep space. The group identified the key points to be discussed between the scientific objectives and the engineering capabilities we currently have, in addition to the necessary funding for these projects for the benefit of the space sector. This tension is demonstrated in the two approaches taken by space agencies, the approach of science is the goal and the technological benefit for mission.

To strengthen ties of international cooperation with countries and space agencies around the world, more attention should be given to emerging nations in the space sector, as well as to the private sector that is focusing on sustainable space science. Exploration and space resources should be considered a world-wide need and a benefit of all of humanity. Other important issues that were addressed were the possibility of expanding the space industry, taking advantage of novel technology and providing this expertise to developing space nations. Moreover, international space programmes could be developed to exchange information and technology and benefit the evolution of the global space sector and not only major space-faring nations

It is also important to involve the public sector and to create stronger links between the scientific sector and the political sector. The political sector has a great impact on decision making and development of projects that rely on government funding. Funding for space programmes should be shown relative to other budgetary requirements to demonstrate the real cost of space science and exploration to the average citizen. An additional way to achieve sustainable space science and exploration comes from reducing the costs of exploration missions. In recent years, private industry has proposed and begun to implement such missions.

In addition, there has been an increase in commercial and governmental activity in new areas of the space sector such as space mining, space medicine, space tourism, and space security and sustainability. In order to develop these new markets, we must devise international policies in which all nations contribute and form the necessary cooperation links, as well as international regulations necessary to help strengthen the bonds of mutual cooperation that have formed in recent decades among the powers in the space sector. Since the following projects would change humanity's perspective on space, future missions would aid global technological development.

**Investing in Space and The New Space Economy**

The emerging in-space economy is marked by the expansion of activities in Earth orbit (and possibly beyond it) that generate economic value. This includes new approaches to collecting and transmitting data on satellites and the development and deployment of non-traditional services and applications. New approaches include smallsats, CubeSats, constellation concepts, commercial uses of the ISS National Lab, satellite servicing and space debris mitigation services, space mining companies, and commercial space stations. Launch providers are trying to make access to space more affordable through such means as reusability, rideshare services, and smaller launch vehicles focused on smallsats. However, it is still uncertain which approaches will realise dramatic improvements in cost and launch volume. This track will address the variety of factors affecting new commercial activities in LEO/cislunar space, particularly how some companies are tackling the demand side of the equation. How can these new ideas (e.g. establish low-cost launch infrastructure, develop commercial space stations) be successfully implemented? What are the barriers (e.g. technical, policy, financial) that still need to be overcome?

Moderator: Mr Andrew Rush (USA)
Rapporteurs: Jim Behmer (USA), Harriet Brettle (UK)

Delegates

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|---|---|
| Nike Moehle | Switzerland |
| Brandon Seifert | USA |
| Bruno Sarli | Brazil |
| Chris Beauregard | USA |
| Harriet Brettle | UK |
| Justin Park | USA |
| Mansoor Shar | UK |
| Mclee Kerolle | USA |
| Patrick Wessels | USA |
| Christian Arnold | USA |
| Jason Wallace | USA |
| Jacob Hacker | Australia |

The New Space economy discussion was moderated by Andrew Rush, CEO of Made In Space, and began with an analogy to the railroads. Trains become rockets, cargo become satellites, instead of tracks think of low cost access to space, and the end destination is still to be discovered. With this framing we asked ourselves, what is the purpose of the space industry? How will this change in the future and where is the demand for the rapidly expanding space economy coming from? Our group covered a range of topics over the course of the session that included many of the challenges and opportunities that the new space economy brings. We discussed the current state of play, how we got here, where we want the space economy to be in the future, and how we want to get there, all in under two hours.

The space industry has changed rapidly in recent years. Government agencies are no longer the sole providers and users in space as commercial viability becomes more attainable. Increased investment is driving the growth of the industry. In 2015, US$15 billion of investment was channelled into the space sector. This is more than the past 15 years combined.

Andrew shared Made In Space's unique perspective. They believe the New Space economy will be driven by in-space manufacturing and are currently developing such capabilities on the ISS. Future plans include building satellites in space and leveraging the space environment for its unique properties. One example of this is Made In Space's plans to manufacture exotic optical fibres in space that will be higher quality than those made on Earth.

A key theme of the discussion was the role of government in the future space economy and the dynamic between public and private players in the future space industry. Historically, access has been driven by government agencies as they have better resources to invest in the required infrastructure. The group agreed that government will always play a role but noted that the range of clients and providers in the space industry has diversified greatly. A good space industry has diversity on both the supply side and the demand side. Regulation of the industry represents both a potential challenge and opportunity and the group questioned how this will be addressed in the future.

Our group discussed new opportunities for commercial spaceflight including data analytics, in-space communication, and space tourism. There is a demand to get assets into space but the launch bottleneck is a big problem that needs to be addressed. Another constraint is the large upfront costs of space projects.

Our group predicted that the space economy will expand such that the term almost becomes meaningless. As in-space and terrestrial demand increases, companies will no longer define themselves as space companies as space technology provides solutions to customers from all industries.

Brandon Seifert represented the group in a panel discussion to conclude. The key takeaways were that the future for the new space economy is bright. The tracks are being laid, the cargo loaded, and the train is ready and eager to leave the station.

**Security and Sustainability**

Space activities are not merely activities that take place in outer space, isolated from Earth. On the contrary, space activities have a grave impact on both our planet and our long term ability to utilise the space environment. Considering the dual use nature of satellites, for example, we must address the security of commercial and governmental assets and the potential dangers of space weaponisation. The US military is already shifting its mindset and approach towards viewing space as a contested environment. At the same time, growing interest in smallsats and constellation based architectures obligates a discussion of space traffic management and debris mitigation. With the increasing role of the private sector in the space domain, our generation will be challenged to incentivise private enterprises to collaborate and preserve the space environment. These and other issues concerning space sustainability and security will be discussed within this discussion track.

Moderator: Mr. Phil Larson (USA)
Rapporteurs: Justin Kugler (USA), Lauren Smith (USA), Steven Jordan Tomaszewski (USA)

Delegates:

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|---|---|
| Megan Maikell | USA |

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|---|---|
| Steven Jordan Tomaszewski | USA |
| Tara Halt | USA |
| John Bang | USA |
| Amelia Ahner | USA |
| Lauren Smith | USA |
| Nicolas Urias | USA |
| Michael Rutherford | USA |
| Anna Gunn-Golkin | USA |
| Alyssa Deardorff | USA |
| Amelia Bloom | USA |
| Kenneth Harris | USA |

At the 2017 SGFF the Space Security and Sustainability Discussion Group engaged in thoughtful conversations and proposed policy ideas about the future of space security and sustaining the space environment. The group agreed that nation-states around the world depend on space assets for their national security and preserving a stable space environment is in the best interest of all countries.

SGFF members expressed concerns about finding employment in the space industry across national borders. For young space professionals who are passionate about space engineering and want to contribute to our collective space security, it can be difficult to find work due to the current legal structure. The group encourages countries like the US to review their International Traffic in Arms Regulations (ITAR) policy that prevents foreign nationals from working in parts of the national security space sector.

As space debris continues to accumulate, we must work together to find solutions to keep space as free as possible of debris and to minimise collisions. Currently, the US Department of Defense provides collision warning information to satellite operators. Group members pointed out space traffic management responsibilities should be put in the hands of civil agencies in space-faring nations and the United Nations should have an organising body similar to the International Civil Aviation Organization (ICAO) which regulates operational spacecraft. This organisation should work to minimise unwanted impacts in space.

Another way space debris can be mitigated is by agreeing to international standards for deorbiting satellites and by having a regulatory body enforce those standards. Carefully crafted regulations could establish rules of the road for countries to abide by for sending up satellites in the future. This would be the most effective coming from an international body like the UN and having buy-in from major spacefaring nations. Our group emphasised the need to address space debris issues as soon as possible, and to not wait until major collisions in space are commonplace.

With companies proposing satellite constellations made up of hundreds or thousands of nodes, the international community needs to work together in order to help track active satellites in orbit. The group recognises the size and primary mission of a satellite will affect what kind of tracking mechanism will be available. Accurate and publicly available satellite ephemeris information will keep space preserved for the future.

Maintaining international cooperation in space will help to maintain collective security in space. Whether a country is engaging in a civil, commercial, or national security mission, international partnerships and agreements ensure countries are working together to achieve common goals for all mankind. Partnerships also make conflict in space less likely. If a country has intent and capability to cause temporary or permanent damage to an operational satellite, they may think twice before targeting a satellite with multi-country ownership. SGFF members encourage nation states to work together on future space missions.

**Space for Earth**

While the general public often perceives space as a distant activity with little bearing on Earth, the growth in space-based navigation, communications, and remote sensing capabilities has translated to a more connected and self-aware world. Yet untapped opportunities remain to leverage space for the benefit of life on Earth. In which ways might space services be designed, implemented, and marketed to create value? How can increased accuracy from new GNSS like Galileo impact industry and government operations, or even create entirely new services? Does the launch of new systems leveraging advanced technology and unique architectures offer a new opportunity to address challenges such as disaster response and mitigation? How can space-based assets contribute to sustainable development, aiding efforts to optimise economic growth, monitor natural resources, and build stable societies? How should civil and commercial opportunities and obligations be balanced, to effectively support citizen needs? What role might space play in the rise of Big Data? This discussion track will explore the ways in which satellites impact life on Earth, and how we can further leverage the space activities of tomorrow to enhance the societal and commercial return.

Moderator: Mr Carlo des Dorides (Italy)

Rapporteurs: Carolyn Belle (USA), Oniosun Temidayo Isaiah (Nigeria), Andreas Winther Rousing (Denmark)

Delegates:

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| PJ Valenzuela | USA |
| Rachel Narciso | USA |
| Temidayo Oniosun | Nigeria |
| Brandon Boese | USA |
| Marcia Fiamengo | USA |
| Elvis Silva | USA |
| Travis Doom | USA |
| Patricia Randazzo | USA |
| Danielle Wood | USA |
| Jillianne Pierce | USA |
| Lauren Badia | USA |

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| Andreas Winther Rousing | Denmark |

DISCUSSION POINTS

While the general public often perceives space as a distant activity with little bearing on Earth, the growth in space-based navigation, communications, remote sensing, and climate monitoring capabilities has translated to a more connected and self-aware world. Yet, untapped opportunities remain to leverage space for the benefit of life on Earth. This discussion track addressed numerous questions including what is considered space for Earth, how to best provide incentives, appropriate regulatory and policy environment, and how to sustain public interest.

The group considered whether it was a public or private sector role to collect data and provide connectivity, and that ultimately we are all communicators and have many different ways to educate people on the role of space in their everyday life. It was noted that a large amount of data is already available for free, such as through the LandSAT program, and more attention must be given to how we can communicate this and ensure these resources are placed in the right hands. A method of doing this is the establishment of more regional working groups and conferences to aid in communicating this discussion to both local leadership and diverse commercial actors. Additionally, the critical challenge of climate change was a topic which the group agreed should be addressed by space resources, and that ultimately, space for Earth is a system of systems consisted of GNSS (navigation), remote sensing, and communications.

The group identified numerous recommendations for future action in this area. First, UN policies can be shaped to aid countries with very low Gross Domestic Product (GDP): top space agencies and commercial companies can make space data available to them for research purposes. Regulations should ensure more interoperability and a collaborative environment, control how many systems are launched, and propose deorbiting methods to curb space debris. More ambitious regulatory steps and guidelines should be established during the upcoming UNISPACE+50, especially with regard to small satellites. We should think more in terms of developing a few very large systems instead of multiple smaller ones.

Additionally, the predicted growth of the private space sector also resulted in recommendations from the discussion group. Specifically, additional UN regulations will be required to address issues such as a potential space data monopoly through a few private actors like Google and SpaceX's global internet project. These regulations should be formed on the basis of collaboration between the governmental and private entities in question. Regulations regarding open space data is the most important outcome, since making some space data available for free will enable us to solve some global problems on a large scale. We can learn also learn from Africa. For example, utilising satellite data such as LandSAT has helped thousands of research projects in the continent, especially regarding agriculture, climate change, urbanisation, land use/land cover, surface temperature measurement, border monitoring, and elimination of criminal activities such as slavery. Serious advocacy must be undertaken for the data that is currently free that most people are not aware of, such as GNSS and climate/environmental monitoring data, to boost awareness and positive outcomes.

Overall, the group concluded that while the whole space industry dreams of making Mars more like Earth, we should stop making Earth like Mars and also focus on using space technologies to solve strategic problems in all parts of the world, especially with regards to the global issue of climate change and global warming.