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2015 Commercial Space Industry Snapshot as Seen Through the Eyes of the International Symposium for Personal and Commercial Spaceflight (ISPCS)

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Abstract
The International Symposium for Personal and Commercial Spaceflight (ISPCS) is a nonprofit independently run annual event, that has taken place these past 11 years, whose speakers capture the growth and diversification of the global commercial space industry in the form of short powerful talks. Hence, it was appropriate that a 2015 snapshot of the commercial space industry should look at this body of experience and knowledge. The key developments, the key players and an accurate state of the industry are hereby presented through the eyes of the ISPCS from this past eleventh symposium that spanned two days and was held in New Mexico. The latest developments include the Lynx, the crewed Dragon, LauncherOne, and the Dream Chaser®.

Keywords: Commercial Space Operations, International Symposium for Personal and Commercial Spaceflight (ISPCS), Secure World Foundation, Orbital ATK, American Institute of Aeronautics and Astronautics (AIAA), Blue Origin, The Boeing Company, XCOR Aerospace, National Center for Women and Information Technology (NCWIT), Northrop Grumman, United Launch Alliance (ULA), Virgin Galactic, NASA, DARPA, ISS, Center for the Advancement of Science in Space (CASIS), Spaceflight Industries, Commercial Spaceflight Federation, SpaceX, Sierra Nevada Corporation's Space Systems, LORD Corporation, Mojave Air & Space Port, Skybox Imaging, Bessemer Venture Partners, X2nSat, ARCA Space Corporation, Acme Advanced Materials, Inc., Cottonwood Technology Funds, Made in Space.

2015 Commercial Space Industry Snapshot as seen through the eyes of the International Symposium for Personal and Commercial Spaceflight (ISPCS)

Introduction

This 2015 industry snapshot of global commercial space operations is depicted here as seen through the eyes of the International Symposium for Personal and Commercial Spaceflight (ISPCS). The reason for this snapshot is to inform the reader of the current state of events in this exciting and emerging industry, and, more importantly, to inspire a new generation of thinking and growth. The ISPCS was chosen as a field of vision because for the past 11 years this symposium has brought together the brightest and most entrepreneurial minds in the industry, to inform, educate and excite! The paper is laid out in the following format. First, the author gives a brief introduction to ISPCS, the curator and the two moderators of this 2015 symposium. Then, for each of the 27 topics, that were showcased over the course of two days in the form of presentations or panels, the author first describes the company or companies involved, followed by biographies of the speaker(s), and finally a thorough description of the heart of the presentation.

The International Symposium for Personal and Commercial Spaceflight (ISPCS)

Since 2005, the ISPCS has been a nonprofit independently run event whose speakers capture the growth and diversification of the global commercial space industry in the form of short powerful talks (ISPCS, n.d.a). Today, in its 11th year, the impact of the commercial space industry exceeds all expectations. Its contractors, suppliers, government partners, and entrepreneurs demonstrate broad, tangible added value to investors and taxpayers (ISPCS, n.d.a). Each year, the ISPCS offers an intimate setting that fosters unrivaled networking, an agenda rich in content, and it is the only conference focused on the commercial space industry (ISPCS, n.d.b).

ISPCS Curator: Pat Hynes

Dr. Hynes serves as the Director of the New Mexico Space Grant Consortium (NMSGC), and National Aeronautics and Space Administration (NASA) Experimental Program for Competitive Research (EPSCoR). In her role as NMSGC Director, she became involved in the development of Spaceport America and commercial space programs in 1991. In 2005, she co-founded ISPCS with Bill Gaubatz. And in 2009, with proceeds from ISPCS, she founded the Student Launch Program, which provides annual access to space from Spaceport America for research experiments. She is a graduate of New Mexico State University (NMSU) with a Ph.D. in Business Administration, and graduate of the International Space University (ISU) Executive Management Course in 2014 (ISPCS Speaker Biographies, 2015a).

ISPCS Moderator: Ariane Cornell

Ms. Cornell works on the Strategy and Business Development team for Blue Origin, LLC, which is a developer of vehicles and technologies to enable human space transportation. At Blue Origin, she focuses on the rocket engine and astronaut portfolios. Ariane was formerly based in Vienna, Austria as the Executive Director of the Space Generation Advisory Council (SGAC) in Support of the United Nations (UN)

Programme on Space Applications. She headed SGAC's delegations to international conferences and the UN, as well as ran the organization's operations, business development, strategy, and policy output. Ariane has supported the international aerospace community in other capacities and organizations. She has 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) (ISPCS Speaker Biographies, 2015b).

Previously, Ariane worked in international management consulting, first with Accenture based in San Francisco and then with Booz Allen Hamilton in Washington, DC. With Accenture, she lived and worked on Information Technology (IT) projects in the Philippines, South Africa, Brazil, and the US. With Booz Allen Hamilton as a senior consultant in the aerospace and defense commercial consulting group, she helped develop strategies and solve operational issues for executives of the world's top aerospace and defense companies (ISPCS Speaker Biographies, 2015b).

ISPCS Moderator: Wayne Hale

Mr. Hale is Director of Human Spaceflight for Special Aerospace Services of Boulder, Colorado. He retired from NASA in 2010 as the Deputy Associate Administrator of Strategic Partnerships, Space Operations Mission Directorate. Mr. Hale has previously served as the Space Shuttle Program Manager and the Shuttle Launch Integration Manager. He was a Space Shuttle Flight Director for 40 Space Shuttle flights, and prior to that a Propulsion Officer for 10 early Space Shuttle flights (ISPCS Speaker Biographies, 2015c).

Mr. Hale currently serves as a Member at Large of the NASA Advisory Council, which by federal law gives direction and advice to the NASA administrator on policy and strategy for the nation's federal space program. Mr. Hale holds a Bachelor of Science degree in Mechanical Engineering from Rice University and a Master of Science degree in Mechanical Engineering (ISPCS Speaker Biographies, 2015c).

Topic 1: What would YOU do with Million$ of Dollar$?

Cynda Collins Arsenault, Co-Founder, Chairman of the Board, and President of Secure World Foundation (SWF), gave this spotlight talk.

Secure World Foundation (SWF)

SWF, with offices in Colorado and Washington, DC, envisions the secure, sustainable and peaceful uses of outer space contributing to global stability on Earth. To this end, SWF works with governments, industry, international organizations and civil society to develop and promote ideas and actions for international collaboration that achieve the secure, sustainable, and peaceful uses of outer space (SWF, 2011).

SWF performs their mission because they believe the following to be true. With the end of the Cold War and rapid spread of access to information, more of humanity is seeking to obtain the security and socioeconomic benefits that space systems can provide. This trend, in turn, is promoting rapid growth in the number of space actors. The growth in stakeholders benefitting from space systems has exposed the limitations of existing global legal, policy, technical, and operational regimes to preserve the space environment. At this point, just one half century into the Space Age, the Foundation believes it has a unique opportunity to play a role in establishing the secure and sustainable use of the space domain. Central to this opportunity are: (1) increasing the knowledge about the space environment and the need to maintain it; (2) promoting international cooperation and dialogue; and (3) helping all space actors realize the benefits that space can provide (SWF, 2011).

SWF employs the following three methods to achieve their mission: (1) *Informing* – the Foundation generates research and analysis for decision-makers to promote the creation of sound policy and raise awareness of key issues that may threaten the security, sustainability and utility of outer space; (2) *Facilitating* – the Foundation convenes timely public and private meetings with stakeholders on key issues to encourage discussion and constructive dialogue for the next steps in support of its mission; and (3) *Promoting* – when viable solutions or next steps become apparent, the Foundation formulates and disseminates policy positions that are aligned with its vision and mission in order to move them from idea to implementation (SWF, 2011).

Co-Founder, Chairman of the Board, and President: Cynda Collins Arsenault

Cynda Collins Arsenault is Co-Founder, Chairman of the Board, and President of SWF, an operating foundation working towards the secure and sustainable use of outer space for the benefit of humanity. She has 40 years of experience in non-profit work including peace and justice, criminal justice, mental health, disability rights and environmental issues. She is also on the family Boards of One Earth Future and the Arsenault Family Foundation (ISPCS Speaker Biographies, 2015d).

Her interests extend from her local community to outer space. Starting out as a Girl Scout and 4H Club leader, she has served in numerous leadership roles on behalf of women and people with disabilities. In her personal philanthropy she concentrates on the empowerment of women in order to tap into critical skills that women bring to the world for solving the difficult problems we face, with a particular focus on women, peace and security. She is part of the Women's Donor Network, Women Moving Millions and The International Women’s Forum (ISPCS Speaker Biographies, 2015d).

She has also been involved, for many years, in promoting opportunities for people with developmental disabilities and has authored two books on the subject. Her daughter, Erin, was born in 1979 with cerebral palsy, opening Cynda’s world to the value and opportunities for personal growth that people with disabilities bring the rest of us. Her son, John, born in 1985 currently lives in Boulder working as an investment researcher and musician. Erin passed away in 2010 (ISPCS Speaker Biographies, 2015d).

What would YOU do with Million$ of Dollar$?

Cynda Collins Arsenault shared her journey as a philanthropist and the choices she has made. She detailed how she came to establish the SWF working on the secure and sustainable use of outer space for the benefit of humanity. Evident from the passion in her voice, she explained how she joins with women around the world to bring a new perspective to the problems we face. And, in keeping with the theme of the conference, she asked the question of the on-going challenge, does it make a difference?

Looking back at the previous year, Cynda mentioned some of the evidence that SWF has amassed to show that indeed they made a difference and kept their promise of promoting cooperative solutions for space sustainability. Space sustainability is ensuring that all humanity can continue to use outer space for peaceful purposes and socioeconomic benefit now and in the long term. This requires international cooperation, discussion and agreements designed to ensure that outer space is safe, secure and peaceful (SWF, 2015a).

To that end, SWF worked with the United Nations (UN) Committee on the Peaceful Uses of Outer Space (COPUOS) to facilitate in-depth discussion of possible guidelines for the long-term sustainability of space activity. They organized a dialogue in Tokyo on Space Situational Awareness in cooperation with Japan Space Forum and the organizers of the Advanced Maui Optical and Space Surveillance Conference. They also partnered with the Space Foundation to present a forum on radio spectrum allocation and competition issues to the annual Space Symposium in Colorado Springs. Members of SWF staff have testified before the U.S. Congress, briefed the Japanese Diet, presented to sessions organized by the British Foreign Office, and taken leadership roles in capacity building and policy sessions organized by the UN and other international institutions. Following up on 2013 success in helping achieve UN endorsement of the International Asteroid Warning Network and the Space Mission Planning Advisory Group, SWF was actively engaged in the discussions aimed at creating terms of reference for these two new institutions (SWF, 2015b).

Topic 2: Commercial Cargo Resupply Service: Supporting the International Space Station (ISS)

Frank L. Culbertson, Jr., President and General Manager of Orbital ATK's Space Systems Group, gave this keynote address.

Orbital ATK

Orbital ATK's Space Systems Group is one of the world's preeminent satellite builders and advanced space systems providers, offering a broad portfolio of products for commercial, military, scientific and international customers. The group designs, manufactures and operates small- to medium-class satellites for communications, imaging, science and national security space applications. Orbital ATK is also a market-leading supplier of space components that power and enable satellites of all classes, and is pioneering innovative in-orbit satellite servicing technologies. It is also a premier provider of space-related engineering services to government agencies and laboratories (Orbital ATK, 2015).

Orbital ATK brings the efficiency and discipline of fixed-price commercial contracting to the human spaceflight market by providing cargo delivery services to the International Space Station (ISS) under NASA's Commercial Resupply Services (CRS) program. The company's Cygnus advanced maneuvering spacecraft conducts autonomous rendezvous and close in operations with the ISS and also supports future deep-space exploration programs (Orbital ATK, 2015).

Orbital ATK is also an innovator in the development of new atmospheric and space flight systems. From Pegasus, the world's first air-launched vehicle designed to boost small satellites into orbit, and the X-43 hypersonic technology aircraft demonstrator to the Eagles program for Stratolaunch Systems and the VivaSat in-space servicing vehicle, Orbital ATK has been involved in some of the most exciting advanced systems in the aerospace industry (Orbital ATK, 2015).

President, Space Systems Group: Frank L. Culbertson, Jr.

Frank L. Culbertson, Jr. is President and General Manager of Orbital ATK's Space Systems Group. Orbital ATK is a global leader in aerospace and defense technologies, with annual revenues of approximately $4.5 billion and a workforce of 12,500 people. The company designs, builds and delivers space, defense and aviation-related systems for customers around the globe, both as a prime contractor and merchant supplier (ISPCS Speaker Biographies, 2015e).

Mr. Culbertson is responsible for the execution, business development and financial performance of the company's human spaceflight, science, commercial communications and national security satellite activities, as well as Technical Services to various government customers. These include some of Orbital's largest and most important programs such as NASA's CRS initiatives as well as various national security-related programs (ISPCS Speaker Biographies, 2015e).

Previously, Mr. Culbertson served as Executive Vice President and General Manager of the Advanced Programs Group at the Orbital Sciences Corp. Prior to joining Orbital ATK, Mr. Culbertson was a Senior Vice President at Science Applications International Corporation (SAIC), following an 18 year career as a NASA astronaut. He has flown three space missions and logged over 144 days in space as shuttle commander, pilot, and station commander. His last mission launched on the Shuttle Discovery and lasted for 129 days, from August 10 until December 17, 2001, returning on the shuttle Endeavour (ISPCS Speaker Biographies, 2015e).

During that mission, he and his two Russian crewmates, lived and worked aboard the ISS for 125 days which included observing the attacks of September 11, 2001, as the only American in orbit at the time. Mr. Culbertson also held several key management positions within the NASA Shuttle and ISS programs and was Program Manager of the Shuttle-Mir Program (ISPCS Speaker Biographies, 2015e).

Commercial Cargo Resupply Service: Supporting the International Space Station (ISS)

Frank Culbertson provided his perspective on commercial space, both current and future. Culbertson presented an overview of the next Cygnus Cargo Resupply mission to be launched in late 2015. He was of the opinion that in the future, commercial space market forces and the continued use of a commercial service approach would be key to creating a more robust space industry. Orbital ATK is an integral part of that commercial space vision.

In his presentation, Culbertson reminded the audience that in 2005, NASA was charged with the task of stimulating commercial enterprise in space by asking American entrepreneurs to provide innovative, cost-effective commercial cargo and crew transportation services to the ISS. From 2006 to 2013, under the Commercial Orbital Transportation Services (COTS) program, NASA acted as both an investor and advisor. Under this Program and in less than five years, Orbital ATK developed and flew the Antares medium class rocket and the Cygnus advanced maneuvering space vehicle, designed to meet the stringent safety requirements for the ISS operations. Commercial Services were then provided under NASA's follow-on Commercial Resupply Services (CRS) contract (Culbertson, 2015).

Orbital ATK provides cargo up and cargo down to the ISS. In three missions Cygnus has delivered for NASA over 8,360lbs of pressurized cargo. In the Demo Mission, which was fully successful, Orbital ATK delivered 700kg to the ISS and brought back 1000kg. In the Orb-1 Mission, which was fully successful, Orbital ATK delivered 1,465kg to the ISS and brought back 1,461kg. In the Orb-2 Mission, which was fully successful, Orbital ATK delivered 1,664kg to the ISS and brought back 1,650kg. Sadly, the Orb-3 Mission was lost, including 2,290kg of manifested cargo (Culbertson, 2015).

After this, CRS returned to flight planning to deliver cargo to the ISS by December 2015. Within this Orbital ATK plan are the following measures: (1) To return Antares to flight in early 2016 using new, in-production RD-181 engines; and (2) To purchase launch services from Atlas V to launch Cygnus during the Antares down-time. Culbertson reminded the audience that Cygnus was designed to be compatible with multiple launch vehicles. He confidently explained that integration with Atlas V was going very smoothly and scheduled to launch in early December 2015. Furthermore, the updated Pressurized Cargo Module (PCM) configuration of the internal structure allows for higher cargo loads, and thus approximately 3,500kg is manifested on the OA-4. OA-4 preparations are underway with the PCM at Kennedy Space Center (Culbertson, 2015).

Culbertson then addressed how the ISS enables commercialization in Low Earth Orbit (LEO). With the extension of the ISS to 2024, NASA has at least nine more years to accomplish its goals. Among these goals are: (1) The development of a commercial market for human spaceflight in LEO; and (2) Human spaceflight beyond LEO through technology/systems demonstrations. He urged NASA, the FAA and other government agencies to take steps now to promote, protect, and establish commercial activities in LEO. Among these activities he mentioned: (1) Legislation and policies; (2) Simplification of International Traffic in Arms Regulations (ITAR) requirements; (3) Funding; (4) Protection of intellectual property generated from commercial activities; and (5) Developing agreements for commercial transportation and the use of NASA astronauts supporting commercial operations (Culbertson, 2015).

Culbertson revealed Orbital ATK's roadmap for ISS commercialization. This includes four goals: (1) Increased commercial transportation services for commercial ISS experiments using Cygnus, which augments NASA and National Lab ISS utilization; (2) Augmentation of the ISS laboratory equipment with commercially owned and operated equipment; (3) Augmentation of the ISS with a complete commercial module for specialized experimentation; and (4) A free flyer commercial module independent of the ISS (Culbertson, 2015).

Culbertson shared his vision for the possible long-term future for ISS commercialization. He believes the ISS could transition from a government-operated facility to a government-owned – contractor-operated facility. He sees this happening in four ways: (1) Commercial contractors (domestic and potentially international) would operate the ISS; (2) NASA would have access to the ISS for specific activities performed by their astronauts; (3) All transportation and resupply would be managed by the commercial operator; and (4) A large subset of the total research conducted on the

ISS would be performed by commercial astronauts. Furthermore, Culbertson envisions that enhancement or replacement of the ISS elements could use commercially developed and manufactured habitation modules. His presentation concluded on a very inspirational note with the hope that the commercial approach could also be applied from the ISS to Mars and everywhere in between (Culbertson, 2015).

Topic 3: The Multiple, Evolving Roles of Professional Societies

Dr. Sandra H. "Sandy" Magnus, Executive Director of the American Institute of Aeronautics and Astronautics (AIAA), gave this spotlight talk.

American Institute of Aeronautics and Astronautics (AIAA)

The AIAA is the world's largest aerospace professional society, serving a diverse range of more than 35,000 individual members from more than 80 countries, and 100 corporate members. AIAA members are all part of an innovative, high-value profession that helps make the world safer, more connected, more accessible, and more prosperous (AIAA, 2015a).

In addition to membership, AIAA offers five content-specific forums where professionals meet and build connections with experts and researchers in aviation, propulsion and energy, space, science and technology, and defense. The Institute's award-winning publications range from books and standards to peer-reviewed technical journals and their flagship magazine, Aerospace America. In addition, AIAA leads the way on issue advocacy that impacts the aerospace sector, and through the AIAA Foundation, the Institute is committed to providing financial support to engineering-related educational programs that expose young people to the aerospace community and encourage study in the aerospace sciences (AIAA, 2015a).

Executive Director: Sandra H. Magnus

Dr. Sandra H. "Sandy" Magnus is the Executive Director of AIAA, the world's largest technical society dedicated to the global aerospace profession. Born and raised in Belleville, Illinois, Dr. Magnus attended the Missouri University of Science and Technology, graduating in 1986 with a bachelors degree in physics and in 1990 with a master's degree in electrical engineering. She also holds a Ph.D. from the School of Materials Science and Engineering at Georgia Tech (1996) (ISPCS Speaker Biographies, 2015f).

Selected to the NASA Astronaut Corps in April, 1996, Dr. Magnus flew in space on the STS-112 shuttle mission in 2002, and on the final shuttle flight, STS-135, in 2011. In addition, she flew to the ISS on STS-126 in November 2008, served as flight engineer and science officer on Expedition 18, and returned home on STS-119 after four and a half months on board. Following her assignment on Station, she served at NASA Headquarters in the Exploration Systems Mission Directorate. Her last duty at NASA, after STS-135, was as the deputy chief of the Astronaut Office (ISPCS Speaker Biographies, 2015f).

While at NASA, Dr. Magnus worked extensively with the international community, including the European Space Agency (ESA) and the National Space Development Agency of Japan (NASDA), as well as with Brazil on facility-type payloads. She also spent time in Russia developing and integrating operational products and procedures for the ISS (ISPCS Speaker Biographies, 2015f).

The Multiple, Evolving Roles of Professional Societies

Dr. Magnus shared her thoughts on how many engineering and professional societies were founded between 50 and 100 years ago. The founders wanted a place to convene to talk about the advances in their areas of interests, share knowledge, and just hang out with people of like mind. The respective industries and disciplines were small, new and the technology was dynamic. Dr. Magnus went on to explain that today professional societies still provide that place to talk about technology, share knowledge with people of like mind and hang out with one's crowd. But the way people interact and the sharing and flow of information has changed. In addition, societies are being asked to do so much more. In the dynamic world we live in the needs of the industry and technical disciplines are changing rapidly and AIAA, along with other professional groups, must keep up with and anticipate these needs. This spotlight talk focused on the way AIAA is tackling some of these challenges (Magnus, 2015).

One of AIAA's ways to tackle these challenges includes being a leading aerospace publisher. AIAA has earned an international reputation as the preeminent publisher of cutting-edge aerospace books and journals, and the leading source of aerospace industry archives, dating back to the early 1900s. Over the past eight decades, AIAA and its predecessor organizations have published over 300 books and almost 200,000 technical articles. AIAA's current publications include seven technical journals, a magazine, three book series, national and international standards documents, a growing number of e-books and other electronic products, and a full-service, interactive website (AIAA, 2015b).

Another one of AIAA's ways to tackle these challenges includes being a wellspring for information exchange. AIAA organizes and hosts the aerospace industry's most important conferences and events, where aerospace professionals exchange information, present findings, network, and collaborate. Every year, AIAA organizes and hosts some two-dozen conferences on key aerospace topics. Whether it is science and engineering, exploration, navigation, communication, or environmental applications, AIAA brings the aerospace community together to bring the world together (AIAA, 2015b).

Yet another one of AIAA's ways to tackle these challenges includes serving a diverse community by addressing the needs of scientists, engineers and allied professionals who conceive, design, develop, test, construct, and operate air and space vehicles, plus their associated systems and subsystems. Equally important, they reach out to the educators who train the professionals, to the researchers who continuously renew the technology, to the managers who lead their efforts, and to the innovators who generate and nurture new concepts. For all of these professionals, AIAA offers a wealth of benefits. These include resources for practitioners, such as access to market and management information, links to related societies and businesses, career information, and provocative articles with relevant industry insights (AIAA, 2015b).

Finally one of AIAA's ways to tackle these challenges includes being the public policy voice of aerospace. AIAA is the voice of the aerospace profession, giving its members an effective say in policy decisions affecting aerospace. Since 1972, AIAA has contributed technical expertise to Congress and the executive branch, providing accurate information to decision makers and highlighting the crucial role aerospace plays in economic and national security, and in our technological future (AIAA, 2015b).

Topic 4: Making a Difference – Step-by-Step, Ferociously

Rob Meyerson, President of Blue Origin, gave this keynote address.

Blue Origin

Blue Origin is an American, privately funded, aerospace developer and manufacturer set up by Amazon.com founder Jeff Bezos. The company is developing technologies to enable private human access to space with the goal of dramatically lower cost and increased reliability. It is employing an incremental approach from suborbital to orbital flight, with each developmental step building on its prior work. The company motto is "Gradatim Ferociter", which is Latin for "Step-by-Step, Ferociously". Blue Origin is developing a variety of technologies, with a focus on rocket-powered Vertical Takeoff and Vertical Landing (VTVL) vehicles for access to suborbital and orbital space (Blue Origin, 2015).

President: Rob Meyerson

Mr. Meyerson has been the President at Blue Origin, overseeing the steady growth of the company, since 2003. He began his career at NASA's Johnson Space Center, where he worked on the Space Shuttle and X-38/Crew Rescue Vehicle programs, leading the aerodynamic design of the Orbiter Drag Parachute, as well as the overall design, integration and flight test of a gliding parachute for the X-38 project (ISPCS Speaker Biographies, 2015g).

He later served as an Integration Manager at Kistler Aerospace, responsible for the Landing and Thermal Protection systems of a privately funded two-stage Reusable Launch Vehicle, as well as all technical activities related to Kistler's Space Launch Initiative contract with NASA's Marshall Space Flight Center. Rob has a Bachelor of Science degree in Aerospace Engineering from the University of Michigan and a Master's degree in Engineering Management from the University of Houston. He is an AIAA Associate Fellow and serves as an officer of the Commercial Spaceflight Federation (CSF) (ISPCS Speaker Biographies, 2015g).

Making a Difference – Step-by-Step, Ferociously

Blue Origin's motto is "Gradatim Ferociter" or "step-by-step, ferociously." With this in mind, Blue Origin has been working diligently for several years towards making a difference for humanity through enabling an enduring human presence in space. Mr. Meyerson provided an update on Blue Origin's development of launch systems and other technologies.

The first of these technologies is the Astronaut Experience. Meyerson described the capsule that can hold up to six astronauts in multiple capsule configurations. This capsule has the largest windows in spaceflight history, and encompasses a full-envelope escape system. Escape would be available from the launch pad to nominal separation. He explained that the flight would take 11 minutes to complete, spanning over 100km, and providing weightlessness for approximately four minutes (Meyerson, 2015).

The second of these technologies is suborbital research capabilities. Meyerson went on to explain initial capabilities to include the 100km apogee; the three minutes of milli-g accelerations; the Blue Origin payload system or custom interface; and the sales partnership with NanoRacks. He continued with the future capabilities which would include up to six astronauts and/or payload stacks; access to large windows; turnaround as fast as 24 hours; and additional possibilities as market demand grows (Meyerson, 2015).

Meyerson explained the New Shepard Suborbital System where the capsule separates from the booster and lands classically under three parachutes with a cushioning retro-thrust system. He described the vertical landing explaining that upon reentry, airflow through the ring fin shifts the center of pressure. The wedge-shaped fins enhance aerodynamic stability and drag brakes reduce speed by half. Aft fins guide the booster over the pad from altitude. The BE-3 engine throttles down to low power to reduce descent rate to 5mph for landing. Finally, landing gear deploys to cushion the landing. The first flight, on April 29, 2015, reached an altitude of 307,000ft (58 miles or 94km). The BE-3 performed flawlessly, with clean separation, and smooth capsule touchdown. There was an attempt to recover the booster (Meyerson, 2015).

So what are the next steps for Blue Origin? According to Meyerson, the answer is none other than orbital. The orbital launch vehicle will launch for the first time later this decade. There will be a reusable first stage with vertical landing and an expendable upper stage. BE-4 and BE-3U engines will power the vehicle. They will be fully funded and available to all of the launch providers. It is anticipated that it will launch from LC-36 in Florida. He gave a few words about the engines. The BE-3U uses liquid oxygen and liquid hydrogen (LOx/LH2) and produces 150,000lbf thrust in vacuum. It will have a low recurring cost, and the BE-3 variant was demonstrated during flight to space. The BE-4 uses liquid oxygen and liquefied natural gas (LOx/LNG) and produces 550,000lbf thrust at sea level. The BE-4 has been selected by ULA to replace RD-180 on the Vulcan rocket (Meyerson, 2015).

Meyerson concluded with optimism. Blue Origin is growing towards success. The company currently employs approximately 500 people. However, the company has many job openings in Washington and Texas, and should be adding over 300 jobs in Florida. Additionally, the company maintains a year-round internship program. Blue Origin hires a balance of recent graduates and experienced veterans for the long-term (Meyerson, 2015).

Topic 5: What's next for Low Earth Orbit (LEO)? What's after ISS and who will build it and pay for it?

Christopher Ferguson, Deputy Program Manager – Operations Commercial Crew Program, BDS Development, of The Boeing Company, gave this keynote address.

The Boeing Company

The Boeing Company is the world's largest aerospace company and leading manufacturer of commercial jetliners and defense, space and security systems. A top US exporter, the company supports airlines and US and allied government customers in 150 countries. Boeing products and tailored services include commercial and military aircraft, satellites, weapons, electronic and defense systems, launch systems, advanced information and communication systems, and performance-based logistics and training (The Boeing Company, 2015a).

BDS Development brings the best of the best to performance on development programs to ensure first-time quality and repeatable performance. Programs benefit from a skilled and diverse workforce aligned around development excellence and draw directly from a full range of cored air and space vehicle systems, mission systems and test disciplines; engineering best practices; program management and integration. Current BDS Development programs are: Air Force KC-46 aerial refueling tanker; the Air Force's presidential aircraft; CST-100 spacecraft for NASA's Commercial Crew program; NASA's Space Launch System rocket; Boeing's 502 small satellite effort; and BDS work on Boeing's 777X commercial airplane (The Boeing Company, 2015b).

Deputy Program Manager-Operations Commercial Crew Program, BDS Development: Chris Ferguson

Christopher J. Ferguson, a retired US Navy captain and former NASA astronaut, became the Director of Crew and Mission Operations in Boeing's Space Exploration division in December 2011. In his current assignment as the Deputy Program Manager for Operations he is responsible for operations, training and support systems for Boeing's Crew Space Transportation (CST-100) spacecraft. The CST-100 will serve the crew transportation role formerly fulfilled by the Space Shuttle. Ferguson, a NASA astronaut for 13 years, is a veteran of three space shuttle missions. Prior to his service as an astronaut, he was an F-14 Tomcat pilot and test pilot who served aboard the USS Forrestal and USS Nimitz (ISPCS Speaker Biographies, 2015h).

Ferguson has comprehensive oversight for flight crew operations of Boeing's Commercial Crew Transportation System. In this capacity, he works with NASA's office of Human Exploration and Operations, NASA Flight Crew, and Mission Operations Organizations, and Kennedy Space Center's Commercial Crew Program to ensure the Boeing spacecraft design supports NASA's requirements. Ferguson also has a leadership role in developing and testing the crew interfaces to the CST-100 spacecraft including cockpit, space suit and vehicle interior layout (ISPCS Speaker Biographies, 2015h).

Ferguson leverages his space shuttle experience as pilot of STS-115 (Atlantis), commander of STS-126 (Endeavour) and commander of the final shuttle mission, STS-135 (Atlantis). He has logged more than 40 days in space, 5,700 hours in high performance aircraft, and nearly 400 carrier-arrested landings (ISPCS Speaker Biographies, 2015h).

Ferguson has a Bachelor of Science degree in mechanical engineering from Drexel University in Philadelphia and a Master of Science degree in aeronautical engineering from the Naval Postgraduate School in Monterey, California. He holds an FAA Airline Transport Pilot certificate and a Professional Engineer's license. Ferguson has been recognized with numerous service awards and citations, including the Legion of Merit, Distinguished Flying Cross, Defense Meritorious Service Medal, Navy Strike/Flight Air Medal, NASA Distinguished Service Medal, NASA Spaceflight Medals, NASA Outstanding Leadership Medal, Navy Commendation Medals, and the Navy Achievement Medal (ISPCS Speaker Biographies, 2015h).

What's next for Low Earth Orbit (LEO)? What's after ISS and who will build it and pay for it?

What's next for low-Earth orbit? With a finite ISS life cycle on the horizon, what's next for LEO? Boeing's Commercial Crew Program Deputy Program Manager, Operations Chris Ferguson discussed why there is still value in LEO beyond the ISS; who might build future habitats; how one could prove the business case for a continued LEO presence; and who would bear the financial cost.

Ferguson began by stating there is value in the ISS, in terms of ISS research and technology, astronauts' toolkit, and as a deep space proving ground. He used several examples of research and technology, like the water recycler-regenerative environmental control and life support system (ECLSS). As to the astronauts' toolkit he said, "We went to the Moon with slide rules…and tools." So what have we fixed in space? Ferguson reminded the audience that mankind has fixed a watch, stuck doors, eyeglasses, exercise equipment, parachutes, and toilets. So, he continued, "What platform will we use to continue to evolve these skills after ISS?" Furthermore, "Who will build it?" Industry? Government? International Partners? Commercial? (Ferguson, 2015).

Topic 6: Déjà vu All Over Again

John H. (Jay) Gibson II, CEO and President of XCOR Aerospace, gave this spotlight talk.

XCOR Aerospace

XCOR Aerospace is a spacecraft and rocket engineering company based in Mojave, California. They are currently in the process of expanding their corporate and research and development headquarters to Midland, Texas. XCOR Aerospace has pioneered rapid development of long-life, reusable rocket engines for human transport applications for more than a decade, and employs around 100 people worldwide (XCOR Aerospace, 2015).

XCOR Aerospace was created by its four founders in 1999, and originally operated out of their chief engineer's hangar. It has since evolved into a global team of 100-plus highly-skilled, experienced and talented engineers, marketers and salespeople based in three locations: (1) a 10,375 square foot hangar on the Mojave Air and Space Port in Mojave, California; (2) a 60,000 square foot hangar at the Midland International Air and Space Port in Midland, Texas; and (3) the XCOR Space Expeditions sales office in Amsterdam (XCOR Aerospace, 2015).

XCOR is dedicated to making the dream of spaceflight a reality for its customers, investors and employees. They recognize that the best way to make the dream of space flight real is to make it available as frequently as possible to everyone who wants to get there. These days, space is no longer the exclusive domain of governments and institutions like NASA and ESA. Space offers boundless technology and business opportunities. To open the market for commercial space, frequency must increase, costs should drop, and capabilities should dramatically improve. Key to commerciality of space is reusability. Engines, vehicles must have high usage rates, low serviceability requirements (quick turn times) and long life. Through developing and producing highly reusable, and affordable engines and vehicles with low service requirements, XCOR provides platforms to dramatically increase the viability of space missions and opportunities across markets (XCOR Aerospace, 2015).

XCOR Science embodies XCOR's philosophy for customizable, unique and groundbreaking opportunities for science and education payload flights. They believe Lynx research capabilities will have an immediate and measurable impact on their clients' goals, and broadly on STEM education. XCOR Lynx will operate as an FAA AST-licensed suborbital reusable launch vehicle, a platform for a dedicated mission as part of one's space program. XCOR provides opportunities to customize the flight with support from dedicated Payload Integrators. Lynx is easy to design around, with benign environmental conditions, multiple flights per day, opportunities for human-tended payloads, and mission specialist flights. Lynx has applications in planetary science, earth observation, microgravity, atmospheric science, medical/biotech, and many other fields. Lynx spacecraft are available to customers on a wet lease basis (XCOR Aerospace, 2015).

Chief Executive Officer (CEO) and President: John H. (Jay) Gibson, II

Jay Gibson is CEO and President of XCOR Aerospace, overseeing its global business and operations with locations in Mojave, California and Midland, Texas as well as subsidiary XCOR Space Expeditions in Amsterdam (ISPCS Speaker Biographies, 2015i).

Most recently Mr. Gibson served as Senior Vice President, Global Mission Support for Beechcraft Corporation in Wichita, Kansas. Additionally at Beechcraft he served as Vice President of the Special Missions Group and Vice President/CFO of the Defense unit. Prior to joining Beechcraft, he served as the Assistant Secretary of the United States Air Force, and as Deputy Under Secretary of Defense in the Office of the Secretary of Defense. Earlier in his career, Jay served in a variety of leadership and management roles in private industry (ISPCS Speaker Biographies, 2015i).

Déjà vu All Over Again

Just as many companies in rapidly evolving industries, XCOR are seeking how to be market relevant and profitable in the next stages of their lifecycle. Mr. Gibson's role and challenges reflect the evolution of the company and the focus on translating current and future market opportunities into a successful, private enterprise. Experience in the civil aviation sector brings many insights and parallels to this market evolution and its future opportunities.

Topic 7: The Work of Creating Effective Work Teams

Mike Simpson, Executive Director of Secure World Foundation (SWF), chaired this panel, which included presentations by Jill Reckie, Director, Entrepreneurial Alliance and Pacesetters Program at the National Center for Women and Information Technology (NCWIT); Brad McLain, Research Scientist at NCWIT; Doug Young, Vice President, Space Systems Resiliency, at Northrop Grumman; Melissa Sampson, Supply Chain Category Manager and BLAST Facilitator at United Launch Alliance (ULA); and Will Pomerantz, Vice President for Special Projects, at Virgin Galactic.

Secure World Foundation (SWF) (see above)

Executive Director: Mike Simpson

Dr. Michael K. Simpson is Executive Director of the SWF and former President of the International Space University (ISU). Simpson's academic career extends over 36 years and 5 continents. In addition to his tenure at ISU, he has been President of Utica College and the American University of Paris with a combined total of 22 years of experience as an academic CEO. He currently holds a post as Professor of Space Policy and International Law at ISU. In 1993 he retired from the US Naval Reserve with the rank of Commander. He is a member of the International Academy of Astronautics (IAA), a member of the International Institute of Space Law (IISL) and a Senior Fellow of the International Institute of Space Commerce (IISC). His practical experience includes service as an observer representative to the UN Committee on the Peaceful Uses of Outer Space (COPUOS), the Executive Committee and Board of Directors of the World Space Week Association, and the Board of Governors of the National Space Society. He is a founding Trustee of Singularity University and chairs the "Ten-to-the-Ninth Plus" Foundation (ISPCS Speaker Biographies, 2015j).

National Center for Women and Information Technology (NCWIT)

NCWIT is a non-profit community of more than 600 universities, companies, non-profit organizations, and government organizations nationwide working to increase women's participation in computing and technology. NCWIT equips change leaders with resources for taking action in recruiting, retaining, and advancing women from K-12 and higher education through industry and entrepreneurial careers (NCWIT, 2015).

Although women today comprise half the world's population and more than half of the US professional workforce, they play only a small role in inventing the technology of tomorrow. The lack of girls and women in computing and technology represents a failure to capitalize on the benefits of diverse perspectives: in a world dependent on innovation, it can bring the best and broadest problem-solvers to the table; and at a time when technology drives economic growth, it can yield a larger and more competitive workforce (NCWIT, 2015).

NCWIT Alliance member institutions tap into a learning community infrastructure that encourages reform across the full education and career spectrum, uniting the computing community with an amplified voice for the increased participation of all groups. NCWIT programs and campaigns support policy reform in K-12 computing education, improve the visibility of women in computing, encourage high school girls to pursue a computing career, shine a spotlight on the successes of entrepreneurial women, and more. Together, they make more progress than if each organization acted alone. The Academic Alliance members work towards institutional change in higher education. The Affinity Group Alliance brings together national and local Affinity groups that provide support, networking, and professional development. The Entrepreneurial Alliance helps young companies establish diversity at the start. The K-12 Alliance works on the image and teaching of computing. The Workforce Alliance leads efforts in corporate organizational reform. The Social Science Advisory Board advises NCWIT and its members on projects and evaluation (NCWIT, 2015).

Director, Entrepreneurial Alliance and Pacesetters Program: Jill Reckie

Jill Reckie is Director, Entrepreneurial Alliance and Pacesetters Program at NCWIT, where she consults with companies on diversifying their technical workforce and with universities to increase diversity in their computing majors. She serves on the Board of Advisors for Pairin, a fast-growing company offering a Readiness Management System^{TM} with data analytics to help corporations and educational institutions predict and develop behaviors that lead to success in life and work (ISPCS Speaker Biographies, 2015k).

Prior to NCWIT, Reckie held executive leadership roles at AT&T Bell Laboratories (also known as Avaya and Lucent Technologies). As Global Director of Technical Marketing, she led the introduction of emerging technologies in customer locations worldwide and built innovative demonstration labs for sales teams in 90 countries giving them remote access to showcase the latest products and solutions. As Global Director of Executive Relationships, she convened CIOs from Fortune 100 customer companies to synthesize their insights on strategic direction for the $4B company's CEO and senior leadership team (ISPCS Speaker Biographies, 2015k).

Reckie earned her BA in Management Information Systems and minor in Computer Science from Washington State University. She continues to pursue her passion and build upon her expertise for advising teams in the design and execution of new ideas that disrupt the status quo. She is actively involved in her community and nationally. She is a mentor for Bell Middle School who had a STEM project on SpaceX mission to the ISS in June 2015. She is also a volunteer for TEDxMileHigh, Clean Tech Open, Boston Marathon, Rotary International, the US Coast Guard Auxiliary and the American Red Cross. Reckie lives in Golden, Colorado, with her husband Stephan, Managing Director of Angelus Funding an angel investor network, and three children Ashley, Garrett and Stephanie (ISPCS Speaker Biographies, 2015k).

Research Scientist: Brad McLain

Brad McLain is a social scientist serving as a researcher with NCWIT. He also co-directs the Experiential Science Education Research Collaborative (XSci) at the University of Colorado (CU) Boulder. Dr. McLain's research focuses on identity development in relation to STEM learning and career pathways, including the nature and impacts of extraordinary experiences and how such experiences may change our sense of self and life trajectories at different ages. McLain has served as Principal Investigator on several research and project grants funded by both government and corporate entities. He also has extensive experience in informal science education and formal science education and teacher professional development. In his role at NCWIT, Dr. McLain participates in research, research application, and the creation of resources and strategies that organizations can use towards diversification and inclusion in workplace environments and cultures (ISPCS Speaker Biographies, 2015l).

Prior to joining NCWIT, Dr. McLain was an assistant professor of Education at the University of Colorado Denver, an educational researcher at the Space Science Institute, a multimedia instructional designer in the online learning industry, a NASA educational lead for the Space Shuttle Program, the Office of Biological and Physical Research, and the Space Science Mission Directorate, and a social science researcher at the National Center for Atmospheric Research (NCAR). He is also an accomplished filmmaker, having produced and directed three documentary features and dozens of short films. Dr. McLain serves on the Board of Directors for the Jane Goodall Institute, STEM Space, and the Lake Travis STEM Academy. He was Co-Founder of the Xperience STEM conference and www.MySTEMharmony.com and is a nationally recognized speaker. His TEDx and TEDx Youth talks can be found online (ISPCS Speaker Biographies, 2015l).

Northrop Grumman

Northrop Grumman is a leading global security company providing innovative systems, products and solutions in unmanned systems, cyber, C4ISR, and logistics and modernizations to government and commercial customers worldwide. The people at Northrop Grumman hold themselves to a higher standard; both in the products they deliver and in the way they conduct themselves throughout the entire customer service because they are in the business of securing a great deal more than just their place in the market (Northrop Grumman, 2015a).

Their mission is to be at the forefront of technology and innovation, delivering superior capability in tandem with maximized cost efficiencies. The security solutions they provide help secure freedoms for the nation as well as those of our nation’s allies. Squarely meeting their obligations, fiscally and technologically, is not just their business goal, but also a moral imperative. To that end, as they evolve as a company, the responsibility they feel for our country and the citizens and troops they help support grows with them (Northrop Grumman, 2015a).

Northrop Grumman has about 65,000 employees. Net sales in fiscal year 2014 were $24 billion. The company has four business sectors: (1) Aerospace Systems; (2) Electronic Systems; (3) Information Systems; and (4) Technical Services. Northrop Aircraft Company was incorporated in 1939. It has acquired companies that began operating before that date, and there has been successful integration of nearly 20 marquee companies (Northrop Grumman, 2015b).

Vice President, Space Systems Resiliency: Doug Young

Douglas H. Young is the vice president of Space Systems Resiliency for the Space Systems division (SSD) at Northrop Grumman Aerospace Systems, a premier provider of manned and unmanned aircraft, space systems and advanced technologies critical to our nation’s security. In this role, Young leads a singular mission area that focuses on the coordination, development and integration of architectures, technologies and concept of operations (CONOPS) to address the rapidly changing space domain. This activity is closely linked with each of the SSD mission areas to ensure leveraging of investments, concepts and customer feedback. Young also manages emerging military and civil space capability development programs, primarily in the areas of future propulsion systems and rapid access to space. These include the Modular Space Vehicle for the Air Force’s Operationally Responsive Space office and the Composite Tank-set Demonstration for the NASA Space Launch System’s advanced boosters (ISPCS Speaker Biographies, 2015m).

Previously, Young served as vice president of Missile Defense and Advanced Missions for Space Systems, leading two broad, space-based mission areas: Missile Defense and Warning, and Advanced Missions. Programs under his purview included the highly successful pair of Space Tracking and Surveillance System Demonstration (STSS-D) satellites that Northrop Grumman built for the US Missile Defense Agency and operations and support for the country's first early warning satellites, the Defense Support Program. Earlier in his career, Young led Business Development for Space Systems, where he devised and executed growth strategies in support of the division's core programs, including the former National Polar-orbiting Operational Environmental Satellite System, James Webb Space Telescope, Space Tracking and Surveillance System demonstrators, Advanced Extremely High Frequency protected communications satellite payloads and restricted programs (ISPCS Speaker Biographies, 2015m).

Prior to his Business Development role, Young directed the pursuit, capture and execution of more than $150 million in space programs at Aerospace Systems to define and produce next-generation human space exploration systems for NASA's Constellation Program – a series of projects focused on developing launch systems and space transportation systems that will allow humans to conduct extended-duration missions to the moon, Mars and beyond. He joined Northrop Grumman in 1985 as a member of the B-2 bomber development team and, during the next 10 years, progressed through engineering, production, flight test and business development roles on the program (ISPCS Speaker Biographies, 2015m).

Young earned a bachelor's degree in mechanical engineering from the University of Connecticut and a master's degree in systems management from the University of Southern California. He attended a number of executive development programs, including the executive Defense Systems Acquisition Program and the Wharton Advanced Management Program. He is also chairman emeritus of the American Institute of Aeronautics and Astronautics Design Engineering Technical Committee. Northrop Grumman is a leading global security company providing innovative systems, products and solutions in unmanned systems, cyber, C4ISR, and logistics and modernization to government and commercial customers worldwide (ISPCS Speaker Biographies, 2015m).

United Launch Alliance (ULA)

On May 2, 2005, The Boeing Company and the Lockheed Martin Corporation announced their intention to form a 50-50 joint venture, called ULA, combining the production, engineering, test and launch operations associated with US government launches of Boeing Delta and Lockheed Martin Atlas rockets - providing world-class space launch services for the US government at lower cost (ULA, 2015a).

Built on a heritage of sequential enhancements to the Atlas I, II and III families, and developed in partnership with the US Air Force Evolved Expendable Launch Vehicle (EELV) program, the Atlas V provides a single system that can accommodate medium- to heavy-lift missions for US government and commercial launch customers. The continuous improvement approach builds on flight-proven components and previous configurations, including the Centaur upper stage flown on Atlas and Titan vehicles since the 1960s and the RD-180 main engine, which first flew on the Atlas III. The Atlas I, II and III families are now retired (ULA, 2015a).

Delta rockets have been built and launched since 1960. Delta's origins go back to the Thor intermediate-range ballistic missile, which was developed in the mid-1950s for the US Air Force. The Thor, a single-stage, liquid-fueled rocket, was modified to become the Delta launch vehicle, which later evolved into the Delta II. Delta IV was developed in partnership with the US Air Force EELV program and is the most advanced family of Delta rockets. Delta IV blends advanced and proven technology to launch virtually any size medium-to-heavy class payload to space (ULA, 2015a).

ULA was formed to provide reliable, cost-efficient access to space for US government missions. ULA brings together two of the launch industry's most experienced and successful teams – Atlas and Delta – that have supported America's presence in space for more than 50 years. ULA program management, engineering, test, and mission support functions are headquartered in Denver, Colorado. Manufacturing, assembly and integration operations are located in Decatur, Alabama, and Harlingen, Texas. Launch operations are located at Cape Canaveral Air Force Station, Florida, and Vandenberg Air Force Base, California. The ULA team consists of approximately 3,400 employees working at sites across the country. Job category functions include program management, engineering, test, manufacturing, launch site operations, mission and business support (ULA, 2015b).

Atlas and Delta expendable launch vehicles carry payloads to space ranging from weather, telecommunications and national security satellites that protect and improve life on Earth, to deep space and interplanetary exploration missions that further our knowledge of the universe. Launch customers include the Department of Defense (DoD), NASA, the National Reconnaissance Office, the US Air Force and other organizations. Atlas and Delta represent more than 100 years of combined launch experience. Over more than 50 years, Atlas and Delta have launched approximately 1,300 missions (ULA, 2015b).

Supply Chain Category Manager and BLAST Facilitator: Melissa Sampson

Melissa Sampson is a Category Manager for ULA's supply chain. She is the first Category Manager at ULA and leads a multi-functional team to develop and implement category procurement strategies. Category management is a purchasing concept where related products are grouped into categories and these categories are managed as strategic business units. Sampson also leads the Building Leadership and Sustaining Talent (BLAST) program, which is a highly selective, executive leadership development program for mid-career ULA professionals (ISPCS Speaker Biographies, 2015n).

Virgin Galactic

Virgin Galactic is a spaceflight company with the Virgin Group. It is developing commercial spacecraft and aims to provide suborbital flights to space tourists, suborbital launches for space science missions, and orbital launches of small satellites. Further in the future, Virgin Galactic plans to provide orbital human spaceflights (Virgin Galactic, 2015a).

Virgin Galactic is comprised of hundreds of dedicated and passionate professionals – including rocket scientists, engineers, and designers from around the world – united in creating something new and lasting: the world's first commercial spaceline for Earth. Virgin Galactic's team brings decades of experience from organizations like NASA, traditional aerospace firms, and other Virgin companies. Virgin Galactic believes they are at the vanguard of a new space industry that is defining the future of exploration and that they will ultimately make space accessible to more people and for more purposes than ever before. It is a large and difficult undertaking they believe they can help inspire future generations and make it possible to see the beautiful planet we call home from a new perspective (Virgin Galactic, 2015a).

Vice President for Special Projects: Will Pomerantz

Will Pomerantz is the Vice President for Special Projects at Sir Richard Branson's Virgin Galactic. In that role, Will helps extend Virgin Galactic's efforts beyond space tourism, developing efforts such as the LauncherOne orbital launch vehicle for small satellites as well as suborbital research campaigns on board SpaceShipTwo. Will also serves as a Trustee and the Chair of the Board of Advisers for the Students for the Exploration and Development of Space (SEDS), the world's largest student space organization. He is a graduate of Harvard University, the NASA Academy, and the International Space University. Prior to joining Virgin Galactic, he worked at the XPRIZE Foundation, where he served as the primary author and manager of the $30 million Google Lunar XPRIZE and the $2 million Northrop Grumman Lunar Lander XCHALLENGE. Additionally, Will has worked at Brown University, the Futron Corporation, and the United Nations, and he was the co-founder and Editor-in-Chief of SpaceAlumni.com, an early social network for space professionals (ISPCS Speaker Biographies, 2015o).

The Work of Creating Effective Work Teams

Research and practice on effective work teams indicates that the collective intelligence of a team increases relative to diversity. Use of allies and awareness of unconscious bias increases team effectiveness. There is a new call to adventure to reinvent the quest to space. Innovators of a new breed are joining the space community. People are looking for a purpose at work. They want to make a difference in their companies, in the industry and even the world and universe. This was a discussion for everyone in the commercial space industry. It was a new call to adventure to reinvent the quest for space.

Jill Reckie spoke about the work being done at NCWIT, especially by the Pacesetters. She said that what they do best is fix things, break things, and build things. On the topic of women in IT, she said that it is not just about the raw numbers of women in tech, but it is about what kind of meaningful work they do, and what kind of contributions they are able to make alongside of men when they get there. Reckie made a call to action. She recommends the following concrete steps to take today: (1) Make inclusive culture a part of the corporate DNA/brand; (2) Expand sources of future talent; (3) Reduce bias in business processes; (4) Foster inclusivity and culture and hold individuals accountable; and (5) Provide legitimate recognition, credit, and encouragement. Reckie also recommends some things NOT to do: (1) Do not lower your hiring standards, just make sure you are hiring for the things that matter; (2) Do not form development teams with just one woman engineer; and (3) Do not depend only on female employees to advance your gender goals. Additionally, Reckie explained the NCWIT Change Leader Network that includes 650 organizational members. She continued with how NCWIT creates and distributes research-based resources about girls/women and computing. NCWIT aspirations in computing are a full pipeline program: (1) AspireIT MS Outreach (ages 10-13); (2) Award for aspirations in computing (ages 14-18); (3) College/University; and (4) Graduate school/Job. NCWIT does this with aspirations in computing community opportunities, jobs, internships, Student Seed Fund, tech projects, peer support, AspireIT Grants, reunions, visibility, research. Finally, Reckie reminded the audience that since 2007, nearly 4,700 young women have been publicly recognized for their aspirations and achievements in computing and technology (Reckie, 2015).

Brad McLain, a social scientist serving as a researcher with NCWIT presented next on the topic of innovation, diversity, and unconscious bias. He began with the premise that innovation requires diversity, and indeed innovation is a complex process. Diversity benefits creativity. In fact, research shows that groups with greater diversity solve complex problems better and faster than homogenous groups. Citing a study by Woolley, Chabris, Pentland, Hashmi and Malone, McLain added that women improve innovation because the IQs of its individual members do not predict a group's collective intelligence. Indeed, if a group includes more women, its collective intelligence rises (McLain, 2015).

McLain provided some national statistics: (1) Women comprise 57% of US professional occupations; (2) Women hold 26% of US technology jobs; (3) Women make up 19% of US software developers; and yet (4) Only 5% of technology leadership jobs are held by women. He continued with some statistics relating to gender and ethnicity released by Google in June 2014, and by Sendgrid in September 2014. Speaking to diversity overall in technology, McLain continued with more statistics: (1) Blacks and Hispanics comprise 30% of the US population; (2) Black and Hispanic men hold 9% of US computing jobs; and (3) Black and Hispanic women hold 4% of US computing jobs. Top aerospace employers by state include California, Washington, Texas, Ohio, and Alabama. Top aerospace concentrations occur in Washington, Kansas, Alabama, Maryland and Colorado. Sadly, the proportion of women in aerospace, as shown by statistics from 1991 to 2011, has remained consistently low. According to the 2012 US Census Bureau statistics, the aerospace workforce is more mature and aging. The largest percentage of women by age cohort is 35-44 year olds. Nearly 30% of the aerospace workforce is age 55 and over (McLain, 2015).

McLain then asked a very poignant question. "What's going on? Let's cut to the chase. Simple truth. Women aren't broken. Men aren't the enemy. The culprit is societal bias (shared by both women and men) that manifests itself in technical cultures. We know what to do and should do it." He proceeded to show how we all have bias, including himself and those in the audience. So what causes societal bias? In brief, we all have shortcuts; 'schemas' that help us make sense of the world. But our shortcuts sometimes make us misinterpret or miss things. That is unconscious bias. We all bring unconscious bias to work. Unconscious bias permeates recruiting, retaining, and advancing in the following ways: (1) *Hiring* – selecting people like "me"; (2) *Interpersonal effects* – micro inequities, stereotype threat, tokenism, "blindness"; (3) *Task assignment* – Women find themselves in "low status" jobs; (4) *Performance appraisal* – Men appraised for effort, skill – women for collaboration, luck; and (5) *Promotion* – criteria modeled implicitly on existing senior male leaders (McLain, 2015).

Topic 8: The Evolving Landscape of 21st Century Spaceflight

Alexander MacDonald, Program Executive Emerging Space Office, Office of the Chief Technologist at NASA Headquarters, gave this spotlight talk.

National Aeronautics and Space Administration (NASA)

NASA's vision is to reach for new heights and reveal the unknown so that what we do and learn will benefit all humankind. Maj. Gen. Charles Frank Bolden, Jr., (USMC-Ret.) was nominated by President Barack Obama and confirmed by the US Senate as the 12th Administrator of NASA. He began his duties as head of the agency on July 17, 2009. As Administrator, Bolden leads a nationwide NASA team to advance the missions and goals of the US space program. Dr. Dava Newman was nominated in January 2015 by President Barack Obama and confirmed by the US Senate in April 2015 to serve as the Deputy Administrator of NASA. She was sworn in on May 15 and began her duties with the agency on May 18 (NASA, 2015a)

NASA Headquarters, in Washington, provides overall guidance and direction to the agency, under the leadership of the administrator. Ten field centers and a variety of installations conduct the day-to-day work, in laboratories, on airfields, in wind tunnels and in control rooms. NASA conducts its work in four principal organizations, called mission directorates: (1) *Aeronautics* manages research focused on meeting global demand for air mobility in ways that are more environmentally friendly and sustainable, while also embracing revolutionary technology from outside aviation; (2) *Human Exploration and Operations* focuses on ISS operations, development of commercial spaceflight capabilities and human exploration beyond LEO; (3) *Science* explores the Earth, solar system and universe beyond, charts the best route of discovery and reaps the benefits of Earth and space exploration for society; and (4) *Space Technology* rapidly develops, innovates, demonstrates, and infuses revolutionary, high-payoff technologies that enable NASA's future missions while providing economic benefit to the nation (NASA, 2015b).

Program Executive Emerging Space Office, Office of the Chief Technologist: Alexander McDonald

Alex MacDonald is the Program Executive for Emerging Space within the Office of the Chief Technologist at NASA Headquarters. He is recognized as an expert on the economic history of American space exploration and contemporary private-sector space activities. He is the founding program executive of NASA's Emerging Space Office, which was established to conduct economic analysis on emerging commercial space companies. He is also an Executive Staff Specialist at NASA's Jet Propulsion Laboratory, a former research faculty member at Carnegie Mellon University, and has worked for the Universities Space Research Association while at NASA’s Ames Research Center where he worked on small satellite mission designs and served as the first research economist on staff. He was a Clarendon Scholar at the University of Oxford where he obtained his doctorate on the long-run economic history of American space exploration and was an inaugural TED Senior Fellow (ISPCS Speaker Biographies, 2015p).

The Evolving Landscape of 21st Century Spaceflight

NASA's Emerging Space Office (ESO) was formed in recognition of the rising importance of private-sector individuals and organizations that invest their own time and money in space activities. This talk provided a NASA perspective on the evolution of this sector and the implications of the driving forces behind it for the future of American space activities. MacDonald began the spotlight talk with an overview of how NASA engages with emerging space. Several ways this occurs is by: (1) forging the new space economy sparked by the initiative of private entrepreneurs with whom NASA has partnered; (2) economic development and the ISS as NASA seeks and encourages the utilization of the ISS for scientific research by commercial firms, universities, non-profit organizations, and others; (3) enabling commercial crew and cargo access to LEO and beyond through competition; (4) advancing space technology like solar electric propulsion, cryogenic propellant storage and transfer, laser communications, early stage innovations, flight opportunities program, and small satellite programs; (5) NASA facilities and expertise advance space development, for example Ames Research Center provides support in wind tunnel testing, the Armstrong Flight Research Center was able to help SNC perform Dream Chaser® ejection seat and structural design testing, the Jet Propulsion Laboratory (JPL) is working with Masten Space Systems, and the Johnson Space Center is supporting companies like Blue Origin, The Boeing Company, SNC, and SpaceX; (6) the NASA era space economy; and (7) the pre-NASA space economy (MacDonald, 2015).

MacDonald cited the 2010 US National Space Policy. A robust and competitive commercial space sector is vital to continued progress in space. The US is committed to encouraging and facilitating the growth of a US commercial space sector that supports US needs, is globally competitive, and advances US leadership in the generation of new markets and innovation-driven entrepreneurship (MacDonald, 2015).

He continued by outlining the new landscape of space exploration. To this end, he mentioned: (1) private investors and entrepreneurs; (2) emerging space companies; (3) spacefaring nation to nation of spacefarers; (4) garage inventors; (5) challenges and prizes; (6) citizen scientists and crowd funding; and (7) emerging states. He credited the contributions of Andrew Carnegie, Daniel Guggenheim, James Lick, Robert Bigelow, Paul Allen, Jeff Bezos, and Elon Musk to name a few (MacDonald, 2015).

MacDonald concluded with a futuristic look toward emerging space in 2044. He credited several emerging companies: (1) Blue Origin for their goal of lowering the cost of spaceflight to enable markets for exploration; (2) Masten Space Systems for their goal of designing and building reusable launch vehicles intended to serve a niche for low-cost flight experiences; (3) Virgin Galactic for their goal to bring spaceflight experiences to consumers; (4) XCOR for their goal of developing the Lynx series of suborbital vehicles to transport customers and payloads past the threshold of space; (5) Orbital ATK for their goal for reducing the cost of launch and their commercial resupply services to the ISS; (6) SpaceX for their goal to reduce the cost of spaceflight and ultimately, make humanity a space-faring civilization; (7) Stratolaunch Systems for their goal to reduce the cost of access to space with air-launched rockets; (8) ULA for providing launch services to the US government; (9) Planet Labs for operating a constellation of up to 100 small satellites to provide on-demand imagery products; (10) Skybox Imaging for designing and building its own fleet of small satellites, each weighing about 100kg; (11) Bigelow Aerospace for their goal to provide affordable options for people to live and work in space; (12) The Boeing Company for developing a crewed capsule, the CST-100 in collaboration with Bigelow; (13) Sierra Nevada Corporation for building the Dream Chaser®, an orbital vehicle designed to carry seven people and spend months at a time in orbit; (14) Space Adventures whose vision is to open up the space frontier to private citizens and provide access to space resources; (15) B612 Foundation, a non-profit organization that intends to discover and catalog asteroids in the Earth's region of the solar system; (16) Inspiration Mars, a non-profit organization that advocates for a low-cost human Mars flyby mission in 2018 or 2021; (17) Moon Express for their long-term goal to enable commercial mining on the moon; and (18) Planetary Resources for their plans to mine a near-Earth asteroid for raw materials (MacDonald, 2015).

Topic 9: Disruptive Technologies for New Space Future

Pam Melroy, Deputy Director, Tactical Technology Office at Defense Advanced Research Projects Agency (DARPA), gave this keynote address.

Defense Advanced Research Projects Agency (DARPA)

For more than 50 years, DARPA has held to a singular and enduring mission: to make pivotal investments in breakthrough technologies for national security. The genesis of that mission and of DARPA itself dates to the launch of Sputnik in 1957, and a commitment by the US that, from that time forward, it would be the initiator and not the victim of strategic technological surprises. Working with innovators inside and outside of government, DARPA has repeatedly delivered on that mission, transforming revolutionary concepts and even seeming impossibilities into practical capabilities. The ultimate results have included not only game-changing military capabilities such as precision weapons and stealth technology, but also such icons of modern civilian society such as the Internet, automated voice recognition and language translation, and Global Positioning System receivers small enough to embed in myriad consumer devices (DARPA, 2015).

DARPA explicitly reaches for transformational change instead of incremental advances. But it does not perform its engineering alchemy in isolation. It works within an innovation ecosystem that includes academic, corporate and governmental partners, with a constant focus on the Nation's military Services, which work with DARPA to create new strategic opportunities and novel tactical options. For decades, this vibrant, interlocking ecosystem of diverse collaborators has proven to be a nurturing environment for the intense creativity that DARPA is designed to cultivate. DARPA comprises approximately 220 government employees in six technical offices, including nearly 100 program managers, who together oversee about 250 research and development programs (DARPA, 2015).

DARPA goes to great lengths to identify, recruit and support excellent program managers – extraordinary individuals who are at the top of their fields and are hungry for the opportunity to push the limits of their disciplines. These leaders, who are at the very heart of DARPA's history of success, come from academia, industry and government agencies for limited stints, generally three to five years. That deadline fuels the signature DARPA urgency to achieve success in less time than might be considered reasonable in a conventional setting. Program managers address challenges broadly, spanning the spectrum from deep science to systems to capabilities, but ultimately they are driven by the desire to make a difference. They define their programs, set milestones, meet with their performers and assiduously track progress. But they are also constantly probing for the next big thing in their fields, communicating with leaders in the scientific and engineering community to identify new challenges and potential solutions. Program Managers report to DARPA's office directors and their deputies, who are responsible for charting their offices' technical directions, hiring program managers and overseeing program execution. Experts in security, legal and contracting issues, finance, human resources and communications also support the technical staff. These are the people who make it possible for program managers to achieve big things during their relatively short tenures. At the Agency level, the DARPA Director and Deputy Director approve each new program and review ongoing programs, while setting Agency-wide priorities and ensuring a balanced investment portfolio (DARPA, 2015).

DARPA benefits greatly from special statutory hiring authorities and alternative contracting vehicles that allow the Agency to take quick advantage of opportunities to advance its mission. These legislated capabilities have helped DARPA continue to execute its mission effectively (DARPA, 2015).

Deputy Director, Tactical Technology Office: Pam Melroy

Ms. Pamela Melroy joined DARPA in January 2013 as the deputy director of the Tactical Technology Office (TTO) after serving as the acting Deputy Associate Administrator and Director of Field Operations in the FAA's Office of Commercial Space Transportation. While at the FAA, Ms. Melroy was responsible for developing human commercial spaceflight regulatory requirements. Ms. Melroy was also the point of contact for interagency policy coordination, coordinating with the White House, NASA, and the Department of Defense (DoD) on space policy. As Director of Field Operations, she was responsible for overseeing and growing activities from three to six field offices supporting operational safety oversight, licensing and inspection of commercial space activities (ISPCS Speaker Biographies, 2015q).

Formerly, Ms. Melroy served as the deputy director, Orion Space Exploration Initiatives at Lockheed Martin Corporation from August 2009 until April 2011. Prior to her position at Lockheed Martin, Ms. Melroy was selected as an astronaut candidate by NASA and held several key positions within the NASA Shuttle program from 1994 until 2009, including crew module lead on the Columbia Reconstruction Team, deputy project manager for the Columbia Crew Survival Investigation Team, and branch chief for the Orion Branch of the Astronaut Office. As a NASA astronaut, she served as pilot on two Shuttle missions (STS-92 in 2000 and STS-112 in 2002), and was the mission commander on STS-120 in 2007. She was the second woman to command a Space Shuttle mission. She has logged over 924 hours (over 38 days) in space (ISPCS Speaker Biographies, 2015q).

Ms. Melroy was commissioned through the Air Force ROTC program in 1983 and attended Undergraduate Pilot Training at Reese Air Force Base in Lubbock, Texas, graduating in 1985. She flew the KC-10 for six years at Barksdale Air Force Base in Bossier City, Louisiana, as a copilot, aircraft commander and instructor pilot. Ms. Melroy is veteran of Just Cause and Desert Shield/Desert Storm, with over 200 combat and combat support hours. In June 1991, she attended the Air Force Test Pilot School at Edwards Air Force Base, California. Upon her graduation, she was assigned to the C-17

Developmental Test Program, where she served as a test pilot until her selection for the Astronaut Program. She retired from the Air Force in February 2007 (ISPCS Speaker Biographies, 2015q).

Disruptive Technologies for New Space Future

DARPA has been involved with critical developments in space technology since being founded in a post-Sputnik world. Innovations in rocket engine technologies, satellites, and space vehicles in the 1960s and 1970s led to significant US space capabilities. Today, the space landscape is rapidly changing and evolving. Increasing launch costs and wait times, supporting an emerging commercial space industry, and the need for real-time space situational awareness have all emerged as issues affecting the nation. In response, DARPA is pursuing a wide portfolio of space domain awareness programs; programs to improve launch flexibility; and new constructs for changing the satellite paradigm. This talk discussed DARPA's vision for affordable flexible launch, rapid small satellites, and space logistics, and its developments for real-time space domain awareness.

Melroy started her presentation by sharing DARPA's mission. DARPA was established in 1958 to prevent strategic surprise from negatively affecting US national security and create strategic surprise for US adversaries by maintaining the technological superiority of the US military. To fulfill its mission, the Agency relies on diverse performers to apply multi-disciplinary approaches to both advance knowledge through basic research and create innovative technologies that address current practical problems through applied research. As the DoD's primary innovation engine, DARPA undertakes projects that are finite in duration but that create lasting revolutionary change (Melroy, 2015).

Melroy addressed the challenges in space. She started with launch flexibility. Current launch has no surge capability and long call-up times. It is currently more than two years to get 'into the queue.' It is akin to a Maserati custom-built production line of a few versus a Ford assembly line of thousands. Additionally, fixed launch sites are vulnerable. Melroy continued with the cost of satellites. DoD payloads launched on Evolved ELV at more than $3B/year and that number is increasing. Small payloads are launched at more than $50M on a few remaining Minotaurs. Budgets are declining across the department. She next addressed space domain awareness. There are approximately more than 16,000 objects in 10^{14} km^3 (240,000 oceans). Approximately 12,020 are in LEO; 1,890 are in MEO; and 1,890 in GEO (Melroy, 2015).

Next, she moved onto DARPA's vision for robust space. For launch, the goal is to have flexible, affordable access, which means affordable, routine and reliable access to space with aircraft-like space access to lower cost and increase capabilities. For satellites, the goal is to change the paradigm of satellite operations by utilizing new satellite architectures for speed and robustness, and GEO space robotics to repair and assemble very large satellites that could not be launched. For space domain awareness (SDA) the goal is real-time space domain awareness and real-time detection and tracking versus catalog maintenance and days to weeks of forensics. Melroy talked about access to space. She shared details about the Experimental Spaceplane (XS-1). The XS-1 aims to lower launch costs and increase space capabilities with aircraft-like space access. Program goals are: (1) To break the cycle of escalating space system costs by: (a) Enabling future space system architectures and (b) Leveraging interests and capabilities of the commercial sector and space tourism; (2) To expand the reusable air-launched concept with a hypersonic vehicle capable of launching 3,000- to 5,000-lbs payloads for $5M with a low-cost upper stage; (3) To mature and integrate technologies supporting launch and hypersonic vehicles; and (4) To demonstrate mission assurance by flying 10 times in 10 days. She addressed Airborne Launch Assist Space Access (ALASA). ALASA aims to provide more affordable, routine and reliable access to space for multiple missions. Program goals are to: (1) Leverage performance, flexibility and re-usability of air launch, and streamlined design and manufacturing; (2) Reduce infrastructure costs by using runways versus fixed sites, automating operations thus avoiding unnecessary services; (3) Launch 100-pound payloads for under $1M per flight, including range costs; (4) Have the satellite on orbit 24 hours after the request; (5) Escape the constraints of fixed direction and location for space launch; and (6) Exercise the concept frequently enough to make operations increasingly efficient and cost-effective (Melroy, 2015).

Melroy shared details about the Payload Orbital Delivery (POD) System, which is a standardized mechanism designed to safely carry and release in GEO a wide variety of payloads aboard commercial communications satellites. The primary goal is to increase opportunities for small mass (approximately 70-100 kg) to many orbits (including GEO) as well as high-tempo launches. POD payload is agnostic to the launch vehicle, interfacing instead with the GEO host spacecraft. Another goal is to provide opportunities for rideshare and separation from a host with adjustable, precise and reliable payload ejection. This would include low POD tumble rates for safe release and low dynamic disturbance to host. Lastly, another goal is to increase responsiveness by: (1) efficient integration, testing and qualification, and minimized need for re-verification, allowing for late integration to the hosting satellite; and (2) flexibility in payload geometry and CG location (Melroy, 2015).

Next, Melroy presented on satlets, a new low-cost, modular satellite architecture that can scale almost infinitely. Satlets are small modules that incorporate multiple essential satellite functions and share data, power and thermal management capabilities. Satlets physically aggregate in different combinations that provide capabilities to accomplish diverse missions. She shared details about the eXperiment for Cellular Integration Technologies (eXCITe) in orbit 450x720 98 deg next year with life 2-8 weeks and launch 1 of 5 payloads on a SHERPA. Mission objectives are to (1) demonstrate aggregation ability to withstand launch environment, perform and maintain thermal control, communicate with the ground, reconstitute traditional spacecraft bus capability; and (2) demonstrate aggregation ability to support a simple and a complex payload (Melroy, 2015).

Melroy gave a three-part presentation on GEO Robotic Servicing. First, the goal is to provide unparalleled high-resolution images on request of spacecraft experiencing anomalies. Inspections would be enabled by a RMMV with a sensor suite and dexterous arms with cameras: (1) stand-off inspections (50m-1km); (2) close inspections (5m-50m); and (3) docked inspections. Second, the goal is to cooperatively move spacecraft in orbit, recover spacecraft in off-nominal orbits and extend lifetimes through propellant conservation. This includes N/S station keeping recovery; end-of-life to GEO graveyard; and repositioning within the GEO belt. Thirdly, the goal is to assist spacecraft experiencing anomalies, helping to ensure that missions can be completed at maximum performance. This means free stuck appendages, a supplement attitude control, and perform docked inspections. Melroy concluded this portion with the statement that GEO servicing could build confidence to transform the entire space architecture (Melroy, 2015).

The next information that Melroy shared dealt with OrbitOutlook. Its goal is to leverage hundreds of available, low-cost assets to increase coverage and persistence of tracking space objects. OrbitOutlook aims to integrate space surveillance data from non-traditional DoD sources, such as Commercial, Academia, and International partners. OrbitOutlook also aims to establish processes to verify information assurance and data quality and develop characterization and Indications and Warning (I&W) techniques. Melroy then explained Hallmark: Real-Time Space Domain Awareness that aims to provide US senior leadership the tools needed for real-time understanding and evaluation of the space environment. Program goals are to: (1) perform real-time information fusion, including course of action (COA) generation and execution support; (2) ingest source-agnostic information; (3) use automation algorithms as decision aids to meet specific timelines; and (4) develop 3-D visualization containing intuitive commander operating picture. In closing, Melroy urged the audience to stay tuned because TTO continues to pursue new technology across multiple domains with an emphasis on space and enhancing the future ground combat squad (Melroy, 2015).

Topic 10: From Suborbital to Low Earth Orbit: How the ISS National Laboratory is Providing Opportunities for New Space Commercialization

Gregory H. Johnson, President and Executive Director at Center for the Advancement of Science in Space (CASIS), gave this keynote address.

Center for the Advancement of Science in Space (CASIS)

In 2011, NASA chose CASIS to be the sole manager of the ISS US National Laboratory. The mission of CASIS is to maximize use of this unparalleled platform for innovation, which can benefit all humankind and inspire a new generation to look to the stars. The organization has been awarded by NASA the responsibility of inciting the imagination of entrepreneurs and scientists alike, accelerating and facilitating space-based research as well as creating public awareness of National Lab research and making space science more accessible to the world (CASIS, 2015).

By carefully selecting research and funding projects, by connecting investors looking for opportunity to scientists with great ideas, and by making access to the station faster and easier, CASIS will drive scientific inquiry toward developing groundbreaking new technologies and products that will tangibly affect our lives. To accomplish these goals, CASIS has at its disposal several tools, resources and capabilities: (1) *Seed money* – Some $3 million is available to help fund promising research projects and product development. CASIS can also connect researchers with third-party investors and financiers; (2) *Expertise* – Seasoned professional aerospace teams are on hand to help develop payloads and integrate systems. Experts can also help with post flight data analysis; (3) *Access to launch* – CASIS works with proven launch providers around the world to get the payload to station; (4) *Administrative support* – CASIS is set up to cut through red tape to facilitate quick access to space;

and (5) *Educational outreach* – By working with NASA, commercial partners, foundations, universities and new technology companies, CASIS can create projects and curricula to teach and inspire students across the country (CASIS, 2015).

President and Executive Director: Gregory H. Johnson

Gregory H. Johnson (Colonel, USAF Ret.) is the President and Executive Director for CASIS. Johnson has served in a variety of leadership roles in the government and is a former fighter pilot, test pilot, and NASA astronaut. He is a veteran of two space shuttle flights, STS-123 and STS-134, aboard Space Shuttle Endeavour. Johnson joined CASIS in 2013 (ISPCS Speaker Biographies, 2015r).

From Suborbital to Low Earth Orbit: How the ISS National Laboratory is Providing Opportunities for New Space Commercialization

Mr. Johnson provided an overview of the emerging commercial market commonly referred to as New Space. Mr. Johnson characterized the growing pipeline of opportunities, from suborbital flight options to use of the world's most unique laboratory aboard the ISS, and how companies from small startups to large corporate enterprises are looking to space as the next great emerging industry. He also described how CASIS is assisting researchers across a broad spectrum of companies and institutions to access the ISS National Lab, and the part that CASIS strives to play in being a catalyst for New Space.

Topic 11: Does Persistence Pay?

Peter Wegner, Chief Technology Officer (CTO) at Spaceflight Industries, gave this keynote address.

Spaceflight Industries (Spaceflight)

Spaceflight is a next-generation space products and services company that is transforming how satellites are built, launched and operated. Through its wholly owned subsidiaries Spaceflight Systems and Spaceflight Services, Spaceflight is streamlining the process and reducing the cost to access and operate in space. Jason Andrews co-founded Andrews Space in 1999 with the mission to be a catalyst in the commercialization, exploration and development of space. Today the company produces affordable, high-performance commercial satellite components and spacecraft. Andrews founded Spaceflight Services, the "space logistics company," in 2010 to provide cost-effective, commercial "rideshare" launch services that open up access to space for more organizations and applications. In 2014, Spaceflight announced Spaceflight Networks, a service dedicated to cost-effective spacecraft communications and operations for small-satellite customers. Under Andrews' direction, all of these companies were combined and rebranded under the Spaceflight name in 2015 to form Spaceflight Industries (Spaceflight, 2015).

CTO: Peter Wegner

Dr. Peter Wegner is the CTO of Spaceflight. Peter has more than 20 years of experience in the research, development, design and operations of advanced spacecraft, rockets, and ground control systems. Prior to joining Spaceflight Peter held a Director-level position with USU/Space Dynamics Lab where he led investments in new technologies and systems to solve some of the Nation's most critical emerging space problems. Dr. Wegner was also a founding member and ultimately the Director of the DoD's Operationally Responsive Space Office at Kirtland AFB, New Mexico, where he directed a more than $120M/year budget and a more than 60 person staff chartered with the responsibility for implementing a national strategy to develop new and innovative techniques to design, build, test, and operate space systems to support DoD missions. This included developing the ability to rapidly reconstitute and augment critical space capabilities in a time of crisis. Dr. Wegner has also held positions as the Technical Advisor to Air Force Space Command Directorate of Requirements and a Research Engineer with the Air Force Research Laboratory Space Vehicles Directorate where he developed many key innovations such as the EELV Secondary Payload Adapter ("ESPA Ring") that has helped open the door for many small satellite programs to find a ride into space. Dr. Wegner has been a lead inventor and co-inventor on five US patents (ISPCS Speaker Biographies, 2015s).

Does Persistence Pay?

The first "new space bubble" burst when LEO satellite communications companies such as Teledesic and Iridium along with supporting launch companies like Kistler Aerospace were put out of business by the rapid proliferation of ground based fiber in the mid-1990s. The second "new space bubble" consisted of government's investments in small satellites and small rocket programs in the early 2000's; including the TacSat series and ORS Office in the DoD and "Faster-Better-Cheaper" in NASA. This "new-space" bubble burst when these investments failed to offset investments in "Big Space Programs" and to become permanent programs of record. Dr. Wegner asked whether this third new space bubble would burst? Is anything different this time? Will the desire to know all things about our planet in near real time feed the business case for large numbers of small imaging satellites circling the globe? This talk explored these themes and made a case for "Persistence pays!"

Dr. Wegner began with the statement from Northern Sky Research that there has been more than $1.5B in NewSpace Investments and most have not launched anything yet. He poses the big bet – global, real-time market intelligence… volumes in algo trading and high frequency trading (HFT) have increased substantially over the past few years in the cash segment from 17% on NSE and 11% on BSE in 2011, respectively, to around 40% of total trades in both the exchanges by March 2015. Next he shared what is happening at Spaceflight. The company produces components, buses, and spacecraft to enable high performance nanosat and microsat missions. Spacecraft platforms (buses) include the SENTRY 1000 (10cm X 10cm X-section); SENTRY 2000 (20cm X 20cm X-section); and SENTRY 4000 (40cm X 46 X-section). Fully integrated spacecraft includes the SCOUT 1 meter GSD Imaging Satellite (50kg). Dr. Wegner spoke about Spaceflight Services Commercial Mission Pricing, launch schedule, and the purchase of a falcon 9 launch from SpaceX. He also shared details about plans for 2017 and Sun Synch Express (Wegner, 2015).

Dr. Wegner gave a Spaceflight Networks introduction. Spaceflight provides turnkey communication data services to enable the emerging NanoSat / MicroSat / SmallSat market. They are deploying a global ground network that provides low and high bandwidth connectivity using UHF, S-band and X-band links. They are developing spacecraft radios that seamlessly integrate with this ground network to simplify spacecraft development and minimize operating costs for our customers. A dedicated antenna lease includes 24/7 use of a single antenna with S-/X-Band for $50,000 per month and UHF for $3,000 per month. On demand access involves use of an antenna on an “as needed” basis to support your spacecraft mission priced at: (1) S-/X-Band for $19.95 per minute and (2) UHF for $1.95 per minute. Dr. Wegner mentioned that BlackSky plans to deploy 60 spacecraft to provide high-resolution imagery of any point on the planet in less than 90 minutes for less than $100 (Wegner, 2015).

Topic 12: Making a Difference – One Future Space Leader at a Time

Eric Stallmer, President of the Commercial Spaceflight Federation (CSF), gave this spotlight talk.

Commercial Spaceflight Federation (CSF)

CSF is the industry association of leading businesses and organizations working to make commercial human spaceflight a reality. The mission of CSF is to promote the development of commercial human spaceflight, pursue ever-higher levels of safety, and share best practices and expertise throughout the industry. Currently, over 60 businesses and organizations are members of CSF. Executive Members include commercial spaceflight developers, operators, and spaceports. Associate Members include suppliers supporting commercial spaceflight, with recent members including suppliers of mission support services and suppliers of training, medical, and life-support products and services (CSF, 2015).

A board of directors comprised of the entrepreneurs and CEO-level officers who represent their member companies govern CSF. Staff manages day-to-day operations. Industry issues are addressed through committees of principals and industry experts, joint projects with partner organizations, and industry-government collaborative efforts (CSF, 2015).

President: Eric Stallmer

Eric Stallmer is the President of the Commercial Spaceflight Federation (CSF). The CSF is the largest trade organization dedicated to promoting the development of commercial spaceflight, pursue ever-higher levels of safety, and share best practices and expertise throughout the industry. Stallmer most recently served as the Vice President of Government Relations at Analytical Graphics Inc. (AGI). Stallmer joined AGI in 2002. During his time at AGI, Stallmer represented AGI’s commercial off-the-shelf (COTS) products and technology to defense, intelligence, Congress, and civil government sectors within the aerospace industry (ISPCS Speaker Biographies, 2015t).

Prior to his time at AGI he was the Executive Director of The Space Transportation Association (STA), a non-profit, industry trade organization providing government representation to companies with a vested interest in the US space launch industry. Stallmer also worked on Capitol Hill in the office of then Congressman Tom Coburn. For over two decades, Stallmer has served as an Officer in the US Army and Army Reserves. He was awarded the Bronze Star Medal for meritorious service while engaged in combat operations while serving in Iraq. He is currently assigned to the

Pentagon in the office of the Deputy Chief of Staff Army for Logistics, G-4 (ISPCS Speaker Biographies, 2015t).

Stallmer earned a Masters of Arts degree in Public Administration from George Mason University, Fairfax, VA, and a Bachelor of Arts degree in Political Science and History from Mount Saint Mary College in Newburgh, N.Y. He and his wife Amy live in Arlington, Virginia with their three children, Charlie, Billy and Catherine (ISPCS Speaker Biographies, 2015t).

Making a Difference – One Future Space Leader at a Time

Mr. Stallmer discussed the Future Space Leaders Foundation dedicated to the career development of young industry students and professionals. The Foundation's Future Space conference series is now in its fourth year and has already raised over $100,000 toward its youth grant program, impacting the lives of awardees that are empowered to present papers at international space symposia. Creating a cohort of young space professionals, the Foundation is aiming to support events hosted by other space non-profits and retain a highly skilled workforce in our industry, making a difference on a very human scale.

Mr. Stallmer began his presentation by calling the audience to make way for the next generation. He identified workforce development as a problem with mostly noise and little action. He urged the baby boomers to pass the torch to Generation X and to the Millennials. New space companies are helping. Established players are finding their mojo. He urged the audience to ensure opportunities to learn and grow! He shared the mission of the Future Space Leaders Foundation, which is to advance learning and professional enrichment of young space professionals and future leaders pursuing careers in the fields of space and satellites. Stallmer shared an upcoming event. This is the Future Space 2015 Conference, taking place on Capitol Hill, with wicked cool topics, and open to Next Generation attendees. He stressed that Members of Congress and Key Administration Officials would be attending and it would be a barrel of fun and insight. Stallmer shared some of the expanding programs: (1) SGAC Space Congress; (2) AAS Goddard Symposium; (3) ISPCS; (4) AIAA Spotlight Awards Dinner; (5) NSC Goddard Memorial Dinner; (6) Space Foundation Fusion Forum; and (7) SEDS Annual Conference (Stallmer, 2015).

Topic 13: A Holistic Approach to Experience Design

Johannes Torpe, CEO and Creative Director of Johannes Torpe Studios, gave this keynote address.

Johannes Torpe Studios

Johannes Torpe Studios is an international interior architecture and design studio based in Copenhagen, founded and creative-directed by Johannes Torpe. Within the company is a team of spatial designers, architects, graphic designers, product designers and furniture designers who draw on their experience from all over the globe when creating custom design solutions to help brands grow. They enjoy things that are playful and magical and have been called unconventional and they wear this with pride (Johannes Torpe Studios, 2015).

They create interior designs that deliver a clear and strong spatial interpretation of their client's brand identity. They deliver design solutions that spark curiosity, through engaging user experiences. They endeavor to change the way people observe, interpret and interact with a space. Ultimately, they add value to brands by creating spaces that tell their brand story with authenticity (Johannes Torpe Studios, 2015).

Their design approach is not based on a particular aesthetic, trend or style, but is individually developed for the who, what, when and why of the client brief. Each client is unique and so is each project. They never do the same thing twice. Working across different areas of expertise, spatial design, branding, furniture design and product design, the collective knowledge and skills within their multidisciplinary team is what allows their studio to design with the bigger picture in mind. This is how they ensure that they deliver consistently thoughtful and holistic design solutions (Johannes Torpe Studios, 2015).

Johannes Torpe Studios work with companies of all shapes and sizes. They engage in a process where they work with their clients, not for them. Their client relationships are built upon a basis of honesty, trust and a shared desire to achieve something that is of significant value (Johannes Torpe Studios, 2015).

CEO and Creative Director: Johannes Torpe

As the founder and vision behind Johannes Torpe Studios, Danish designer Johannes Torpe is a pioneer in the world of lifestyle, design and immersive branding experiences. He delivers thought-provoking solutions in concept design, interior design and industrial design to clients from all regions of the world (ISPCS Speaker Biographies, 2015u).

Since childhood Johannes Torpe has allowed his creative energy and intuition to guide him. With support from his freethinking parents, Torpe has pursued his ventures without any conventional training. His keen eye for emerging trends and a holistic approach to the business of design is the driving force behind his creative consultancy expertise. This has given him the opportunity to surround himself with a team of multi-disciplinary experts from around the world, and the honor of being the first ever Creative Director for luxury design and sound brand Bang & Olufsen (ISPCS Speaker Biographies, 2015u).

A Holistic Approach to Experience Design

This high-energy session gave the audience an insight into one of our generation's leading 'experience' designers. Taking a holistic approach, Johannes delivers interior design to customers seeking the extraordinary in all aspects of their projects. This thought-provoking session demonstrated how good design could turn spatial experiences into something truly magical.

Topic 14: Commercial Cargo Transportation to the ISS – Learning as a Team

Gregory H. Johnson, President and Executive Director, Center for the Advancement of Science in Space (CASIS), chaired this panel, which included Frank DeMauro, Vice President, Human Space Systems, Civil and Defense Division, Space Systems Group, Orbital ATK; Joshua Brost, Business Development, SpaceX; and Mark

Sirangelo, Corporate Vice President, Sierra Nevada Corporation (SNC)'s Space Systems.

Orbital ATK (see above)

Vice President, Human Space Systems, Civil and Defense Division, Space Systems Group: Frank DeMauro

Frank DeMauro is the Vice President of Orbital ATK's Human Space Systems business area and is also Program Director of the Commercial Resupply Services (CRS) program. In that capacity he has managed the development, production and delivery of multiple Cygnus spacecraft and, since 2009, has managed the overall Commercial Orbital Transportation System (COTS) and CRS contracts for Orbital ATK (ISPCS Speaker Biographies, 2015v).

Just prior to becoming the Program Director for the COTS and CRS programs, he held the position of Vice President of Engineering in Orbital ATK's Technical Operations Group. Prior to his role as Vice President of Engineering, Mr. DeMauro managed development programs in Orbital ATK's commercial communications satellite group, which resulted in expanded versions of Orbital ATK's GeoStar-2 satellite platform, which were, in each case, the largest communications satellites built by Orbital ATK. Since joining Orbital ATK in 1991 as a Thermal Engineer, Mr. DeMauro has also held positions in Subsystem Development, Systems Engineering, and Business Development (ISPCS Speaker Biographies, 2015v).

SpaceX

SpaceX designs, manufactures and launches advanced rockets and spacecraft. The company was founded in 2002 to revolutionize space technology, with the ultimate goal of enabling people to live on other planets. SpaceX has over 3,000 employees (SpaceX, 2015).

SpaceX has gained worldwide attention for a series of historic milestones. It is the only private company ever to return a spacecraft from LEO, which it first accomplished in December 2010. The company made history again in May 2012 when its Dragon spacecraft attached to the ISS, exchanged cargo payloads, and returned safely to Earth – a technically challenging feat previously accomplished only by governments. Since then Dragon has delivered cargo to and from the space station multiple times, providing regular cargo resupply missions for NASA (SpaceX, 2015).

Under a $1.6 billion contract with NASA, SpaceX will fly numerous cargo resupply missions to the ISS, for a total of at least 12 – and in the near future, SpaceX will carry crew as well. Dragon was designed from the outset to carry astronauts and now, under a $440 million agreement with NASA, SpaceX is making modifications to make Dragon crew-ready. SpaceX is the world's fastest-growing provider of launch services. Profitable and cash-flow positive, the company has nearly 50 launches on its manifest, representing close to $5 billion in contracts. These include commercial satellite launches as well as NASA missions. Currently under development is the Falcon Heavy, which will be the world's most powerful rocket. All the while, SpaceX continues to work toward one of its key goals – developing reusable rockets, a feat that will transform space exploration by delivering highly reliable vehicles at radically reduced costs (SpaceX, 2015).

Business Development: Joshua Brost

Josh Brost manages SpaceX's civil sales efforts. In this role, he focuses on deepening SpaceX's relationships across each of the NASA centers and identifying opportunities for collaboration. Prior to assuming responsibility for civil sales, Josh led SpaceX's North American commercial sales efforts and signed several notable contracts including Intelsat's and ViaSat's purchases of Falcon Heavy launch services. Before joining SpaceX, Josh worked as an Aerospace Engineer for The Boeing Company and as a Management Consultant for The Boston Consulting Group. Josh earned a Bachelor's degree in Aerospace Engineering from Arizona State University; a Master's degree in Aerospace Engineering from The University of Washington; and a Master's degree in Business Administration from Harvard Business School (ISPCS Speaker Biographies, 2015w).

Sierra Nevada Corporation (SNC)'s Space Systems

SNC is a world-class prime systems integrator and electronic systems provider known for its rapid, innovative, and agile technology solutions. Fast-growing and widely diversified, SNC is a high-tech electronics, engineering, and manufacturing corporation that continues to expand their impressive portfolio of capabilities, programs, products and services. SNC is a privately held company under the leadership of CEO Fatih Ozmen and President Eren Ozmen. Over the last 30 years under the Ozmens' leadership, SNC has remained focused on providing its customers the very best in diversified technologies to meet their needs and has a strong and proven track record of success. Headquartered in Sparks, Nevada, SNC is the Top Woman-Owned Federal Contractor in the US based on its size, significant achievements, and resources to deliver high-technology systems and integration programs (SNC, 2015).

Since SNC was founded in 1963, the company has a strong tradition in developing and providing high technology electronics, avionics, and communications systems. Investing heavily over the years in people, processes, modern facilities, and the state-of-the-art equipment, SNC continues to enhance its technical advantage to provide innovative and cost-effective solutions to exceed its customers' needs. With numerous successful and diverse acquisitions, SNC continues to acquire new capabilities as it expands its tradition of excellence into new growth areas of Telemedicine, Cyber, Net-Centric Operations, Microsatellites, Space Flight and Commercial Aviation (SNC, 2015).

SNC now has an extremely talented workforce of over 3,000 personnel most of who are scientists, engineers, or technical personnel with college or advanced degrees, and all of whom are dedicated to satisfying customers' requirements. The company's six Business Areas operate from 33 locations in 18 states with business divisions in England, Germany and Turkey, along with numerous customer support sites located throughout the world (SNC, 2015).

Corporate Vice President: Mark Sirangelo

Mark Sirangelo is Corporate Vice President, SNC's Space Systems. Recently recognized as the best technology company to work for, SNC is a multi-billion dollar US aerospace and technology company with over 2,800 employees across the US. As head of SNC's Space Systems, Mark Sirangelo has helped to build and grow a product portfolio ranging from small satellites, to space technologies that have enabled over 420 planetary missions such as Curiosity, to the hybrid rocket motors that won the Ansari X-Prize. SNC is also developing Dream Chaser®, an orbital space plane designed with multiple capabilities to transport crew or cargo to low earth orbit. Mr. Sirangelo was formerly the Chairman and CEO of a publicly traded company, SpaceDev, Inc., prior to its merging with SNC and has spent most of his professional life as an entrepreneur founding and leading several successful technology and communications companies (ISPCS Speaker Biographies, 2015x).

Commercial Cargo Transportation to the ISS – Learning as a Team

The Commercial Resupply Services (CRS) contract established a bold new approach for NASA to provide the critical resupply necessary to keep the ISS crewed and operational, allowing the continued execution of cutting edge science experiments in the microgravity environment of LEO. As one would imagine, this new approach caused a clash between the traditional NASA business culture and the entrepreneurial commercial business culture. This panel discussed the various ways that NASA and the commercial companies learned from each other and in the end became better organizations ready for future challenges.

Frank DeMauro reminded the audience that in 2005, NASA was charged with the task of stimulating commercial enterprise in space by asking American entrepreneurs to provide innovative, cost-effective commercial cargo and crew transportation services to the ISS. From 2006 to 2013, under the Commercial Orbital Transportation Services (COTS) program, NASA acted as both an investor and advisor. Under this Program and in less than five years, Orbital ATK developed and flew the Antares medium class rocket and the Cygnus advanced maneuvering space vehicle, designed to meet the stringent safety requirements for the ISS operations. Commercial Services were then provided under NASA's follow-on Commercial Resupply Services (CRS) contract (DeMauro, 2015).

Orbital ATK provides cargo up and cargo down to the ISS. In three missions Cygnus has delivered for NASA over 8,360lbs of pressurized cargo. In the Demo Mission, which was fully successful, Orbital ATK delivered 700kg to the ISS and brought back 1000kg. In the Orb-1 Mission, which was fully successful, Orbital ATK delivered 1,465kg to the ISS and brought back 1,461kg. In the Orb-2 Mission, which was fully successful, Orbital ATK delivered 1,664kg to the ISS and brought back 1,650kg. Sadly, the Orb-3 Mission was lost, including 2,290kg of manifested cargo (DeMauro, 2015).

After this, CRS returned to flight planning to deliver cargo to the ISS by December 2015. Within this Orbital ATK plan are the following measures: (1) To return Antares to flight in early 2016 using new, in-production RD-181 engines; and (2) To purchase launch services from Atlas V to launch Cygnus during the Antares down-time. DeMauro reminded the audience that Cygnus was designed to be compatible with multiple launch vehicles. He confidently explained that integration with Atlas V was going very smoothly and scheduled to launch in early December 2015. Furthermore, updated Pressurized Cargo Module (PCM) configuration of the internal structure allows for higher cargo loads, and thus approximately 3,500kg is manifested on the OA-4. OA-

4 preparations are underway with the PCM at Kennedy Space Center (DeMauro, 2015).

Joshua Brost started his presentation talking about the Dragon, which is the only spacecraft flying that is capable of returning significant amounts of cargo from the ISS. In fact, 10,000 kg of cargo has been delivered to ISS, with 9,000 kg cargo returned to earth. There are eight more cargo missions manifested through 2017. SpaceX is working to make the vehicle reusable on future missions (Brost, 2015).

Mark Sirangelo started his presentation with the SNC Dream Chaser® Program Update. SNC Space Systems has a proven pedigree with extensive capabilities that include: (1) 26 years of space flight heritage; (2) more than 430 space missions supported; (3) 4,000 products delivered with no on-orbit failures; (4) launching approximately every three weeks; (5) more than 70 successful NASA missions; (6) supplier to flagship US government space programs; (7) space relationships in over 20 countries; and (8) certified to all three industry quality and safety standards. When speaking about the Dream Chaser®, Sirangelo emphasized that it is a mature vehicle with the major risks retired. To this end, it is a mature design from ten years of development and five years of NASA Commercial Crew program contracts. The company has verified all system functions using comprehensive hardware and software test beds, and completed more than 1,500 wind tunnel tests. They have flight tested a full scale vehicle to prove aerodynamic performance, as well as completed NASA Thermal Protection System Arc Jet pre-qualification testing. They have hot fired the ORBITEC Vortex engine propulsion system numerous times, and currently are completing the first orbital vehicle structure (Sirangelo, 2015).

Sirangelo continued to describe the Dream Chaser® Cargo System (DCCS), which he referred lovingly to as the best cargo services solution in the world. It is capable as it exceeds all of NASA’s cargo needs. It is safe, using a gentle reentry, runway landing, and all non-toxic propulsion. It is responsive with immediate post-land access to full payload. It is affordable with highly reusable (15x), broad commercial services. It is flexible allowing for cargo disposal and return, and stows in 5m launch fairings. Lastly, it is mature as it leverages more than 40 years of Shuttle/X-plane experience (Sirangelo, 2015).

He continued by mentioning that it assures access to the ISS with multiple launch options. The reasons for this: (1) the fault tolerant folded wing design allows the Dream Chaser® to fit inside Atlas/Ariane standard 5m fairings; (2) it is compatible with multiple launch vehicles/ground systems, e.g. Atlas V, Ariane 5 or 6, Delta IV, Japanese H-IIB/III, and SpaceX Falcon Heavy; and (3) it has responsive cargo access and is designed for multiple mission reusability exceeding the life of the ISS. Continuing to sing Dream Chaser®’s praises, Sirangelo continued by mentioning that the spacecraft provides an enhanced platform for science missions. This is because the Dream Chaser® offers: (1) a microgravity environment; (2) a rapid development timeline; (3) custom or modular hardware tailored to investigator needs; (4) intellectual property rights; (5) frequent re-flight opportunities; (6) low-g reentry and landing site selection; (7) immediate access post-landing; and (8) extended mission duration (Sirangelo, 2015).

Finally, Sirangelo called the Dream Chaser® a true Space Utility Vehicle (SUV) because of its broad appeal, value, and sustainability. It has extensible capabilities for a broad set of LEO Missions beyond the ISS, to name a few: short and long duration standalone science missions, exploration support missions, servicing of future commercial space stations, satellite deployment/servicing/retrieval, earth observation missions, and orbital test bed for exploration technologies and hypersonic flight. The Dream Chaser® maintains an alternate path to crewed capability with dissimilar redundancy. Also, it has capability to land on standard 8,000ft (2,400m) runways, which expands the opportunities for industry and international collaboration. He concluded this outstanding presentation with this quote: Dreams don't have an expiration date! (Sirangelo, 2015).

Topic 15: ULA Product Evolution

Mark Peller, Program Manager, Major Development, United Launch Alliance (ULA), gave this keynote address.

United Launch Alliance (ULA) (see above)

Program Manager, Major Development: Mark Peller

Mark Peller is the program manager for major development at United Launch Alliance (ULA), and in this position he is responsible for the development of Vulcan. Vulcan is ULA's future launch system that builds upon the ULA's extensive Atlas and Delta heritage to provide a competitive product offering to serve a broad spectrum of markets. As the program manager, Peller has overall responsibility for developing the launch vehicle and the supporting capabilities required across the supply chain as well as ULA's production and launch operations to meet the program's objectives (ISPCS Speaker Biographies, 2015y).

Peller began his career with Rockwell International in 1990 as a propulsion engineer supporting the Space Shuttle program. He joined The Boeing Company in 1996 when it acquired the aerospace and defense businesses of Rockwell. Peller moved to the Delta program in 1997 and held various technical and program management positions throughout the development and initial fielding of the Delta IV launch system. Peller continued his work on the Delta program at ULA after the company was formed in 2006. In 2009, he was appointed the product line chief engineer for Delta, where he had overall technical responsibility for the Delta II and Delta IV launch systems. During this period he oversaw 24 successful Delta launches, including the first launch of the Delta IV Heavy configuration from the West Coast. In 2013, Peller transitioned into the role of the director of the ULA Hardware Value Stream where he was responsible for managing the Evolved Expendable Launch Vehicle (EELV) contracts with the US Air Force, and leading the product teams supporting launch vehicle development, procurement, and production (ISPCS Speaker Biographies, 2015y).

Peller holds a Bachelor of Science degree in applied mechanics from the University of California, San Diego, a Master of Science degree in aerospace engineering from the University of Southern California and a Master of Business Administration degree from the University of California, Irvine. He is a licensed mechanical engineer in the state of California (ISPCS Speaker Biographies, 2015y).

ULA Product Evolution

This session reviewed ULA’s history of continual product evolution and their future product development roadmap that leverages the Atlas and Delta experience while incorporating new technology and system architectures to meet the evolving needs of their customers.

Topic 16: The Power of Partnerships with Private Industry

Kathryn L. Lueders, Manager, NASA Commercial Crew Program, gave this keynote address.

NASA (see above)

Manager, NASA Commercial Crew Program: Kathryn Lueders

Kathy Lueders is the manager of NASA's Commercial Crew Program, which is aiding the aerospace industry in the development of safe, reliable and cost-effective crew transportation systems for LEO missions. Systems developed, tested and certified through the program will provide NASA with commercial services to transport astronauts to and from the ISS by the end of 2017. As manager, Lueders oversees program facilitation of integrated crew transportation system development and certification. The program is based at NASA's Kennedy Space Center in Florida and has staff at several of NASA's other field centers including Johnson Space Center in Houston (ISPCS Speaker Biographies, 2015z).

Lueders previously served as the ISS Program's Transportation Integration manager. In that post, she managed the commercial cargo resupply services (CRS) to the space station and was responsible for oversight of the international partner vehicles - the European Space Agency's Automated Transfer Vehicle (ATV), the Japanese Space Agency's H-II Transfer Vehicle (HTV), and the Russian Soyuz and Progress spacecraft (ISPCS Speaker Biographies, 2015z).

Lueders began her NASA career at the White Sands Test Facility in New Mexico in 1992 where she performed as the Shuttle Orbital Maneuvering System and Reaction Control Systems Depot manager. She moved into the ISS Program and served in multiple positions including the deputy manager for ISS Logistics and Maintenance, the Vehicle Systems Integration manager, and the Commercial Orbital Transportation Services Integration manager. She has a Bachelor of Business Administration degree in finance from the University of New Mexico and a Bachelor of Science degree and Master of Science degree in industrial engineering from New Mexico State University (ISPCS Speaker Biographies, 2015z).

The Power of Partnerships with Private Industry

It has been nearly a year since NASA awarded final development and certification contracts to The Boeing Company and SpaceX. In that short amount of time, both companies have made considerable strides in providing America with two transportation systems that will carry NASA and NASA-sponsored crewmembers to and from the ISS by 2017. But what happens after this endeavor succeeds? How far can the market for human space transportation go? Kathy Lueders, manager of NASA’s Commercial Crew Program, discussed the progress achieved as well as the challenges ahead for the agency and its commercial partners. She also talked about the importance of developing a commercial human spaceflight market.

Lueders started off with the reason why it was important that the US have these government and industry partnerships. It ensures America remains a leader in space exploration by facilitating the development of safe, reliable and cost-effective transportation systems. It lays the foundation for future commercial transportation capabilities with applicable requirements, standards and technologies. It encourages industry to apply their most efficient and effective manufacturing and business operating techniques. It allows industry to own and operate their spacecraft, launch vehicle and infrastructure. Government and industry share investments in time, money and resources. NASA's technical expertise and lessons learned are now accessible to industry. It spurs economic growth as potential new space markets are created (Lueders, 2015).

Lueders mentioned that a lot could happen in a year. She was referring to the following. NASA awarded Commercial Crew transportation capability contracts to The Boeing Company and SpaceX in September 2014, and worked shoulder-to-shoulder with The Boeing Company and SpaceX as they design, develop, test, and evaluate their crew transportation systems. Through robust insight and oversight, Commercial Crew is ensuring NASA's safety and performance requirements are met. NASA is ordering guaranteed post-certification missions to account for mission delivery schedules. And NASA is building on their partnerships with other programs and government agencies, such as LSP, ISS, FOD, FAA, NTSB, Air Force and DoD. Astronauts have already begun reconfiguring the ISS for commercial crew spacecraft visiting the orbiting laboratory. Hardware is in flow for unpiloted and piloted flight tests to the ISS. Processing and testing has begun on the International Docking Adapters that will fly to station on cargo resupply missions and serve as connection points for commercial crew spacecraft visiting the orbiting laboratory. Launch site infrastructure and processing facilities along Florida's Space Coast are almost complete. NASA has already selected the group of US astronauts who will train for flight tests to the ISS (Lueders, 2015).

In conclusion, Lueders mentioned the opportunities and challenges ahead. NASA is carrying out concurrent agreements with industry partners, Blue Origin, SNC, and SpaceX to enable that vibrant space market we have all envisioned. NASA is receiving requested fiscal year 2016 funding to meet the 2017 target date and execute firm, fixed-price contract commitments with The Boeing Company and SpaceX. The US is passing an amendment to the Commercial Space Launch Act to add the government astronaut definition. NASA is certifying two US commercial crew transportation systems simultaneously (Lueders, 2015).

Topic 17: NASA's Commercial Crew Program: Experience-Guided Innovation

Kathryn L. Lueders, Manager, NASA Commercial Crew Program, chaired this panel, which included John Mulholland, Vice President and Program Manager for Commercial Programs, Space Exploration, at The Boeing Company; and Garrett Reisman, Director of Crew Operations at SpaceX.

The Boeing Company (see above)

Vice President and Program Manager for Commercial Programs, Space

Exploration: John Mulholland

As Vice President and Program Manager, Commercial Crew Programs, John Mulholland leads Boeing's efforts on commercial crew and cargo programs, including our Commercial Crew Development (CCDev) Space Act Agreement. Mulholland ensures that innovations and capabilities from across Boeing are used in development of space transportation vehicles to support NASA and commercial customers.
Prior to his present position, Mulholland was the vice president and program manager for Boeing's Space Shuttle Program. Mulholland lead The Boeing Company in its role as the major subcontractor to United Space Alliance (USA) in support of its operations contract with NASA's Space Shuttle Program. He was responsible for overall direction and successful execution of Boeing's Space Shuttle Program (ISPCS Speaker Biographies, 2015aa).

Prior to joining The Boeing Company in 2002, Mulholland was employed by NASA. From 1986 to 1996, Mulholland worked at NASA's White Sands Test Facility in New Mexico. From 1996 to 2002, he worked at NASA's Johnson Space Center (JSC) in Houston, Texas, as a space shuttle deputy manager of operations. Mulholland is a graduate of New Mexico State University with a bachelor's degree in chemical engineering and a master's degree in mechanical engineering (ISPCS Speaker Biographies, 2015aa).

SpaceX (see above)

Director, Crew Operations: Garrett Reisman

Garrett Reisman is responsible for working with NASA to prepare SpaceX's Falcon 9 rocket and Dragon spacecraft to carry astronauts. He was the SpaceX project manager for CCDev2 – a $75 Million partnership with NASA to mature the Dragon Spacecraft launch abort system and crew accommodations. Reisman then became the SpaceX project manager for CCiCap – a $460 Million partnership with NASA to complete the design of the Dragon-Falcon 9 crew vehicle, perform hardware testing, ensure astronaut safety and pave the way for NASA certification of the vehicle. Reisman then led the SpaceX proposal team and captured a $2.6 Billion award for CCtCap – NASA's latest commercial crew program intended to complete vehicle certification and fly NASA astronauts to the ISS and back up to seven times. Reisman is currently the Director of Crew Operations, responsible for all vehicle crew interfaces including displays, controls, human factors and crew health and medical issues (ISPCS Speaker Biographies, 2015bb).

Reisman came to SpaceX from NASA where he served as an astronaut starting in 1998. He has flown on two space shuttle missions, during which he logged over three months in space including over 21 hours of extravehicular activity (EVA) in three spacewalks. Dr. Reisman served with both the Expedition-16 and the Expedition-17 crews as a Flight Engineer aboard the ISS (ISPCS Speaker Biographies, 2015bb).

NASA's Commercial Crew Program: Experience-Guided Innovation

NASA and its industry providers are incorporating proven processes and flight test strategies to ensure America has two safe, reliable and cost-effective systems for crew transport to and from the ISS. The Commercial Crew Program developed a solid set of safety and performance requirements based on more than 50 years of human spaceflight experience. The Boeing Company and SpaceX are working to meet those rigorous requirements under their Commercial Crew Transportation Capability (CCtCap) contracts while applying innovations as they bring their systems from drawing boards to launch pads. The primary advantage of this government-industry partnership approach compared to traditional government-run development programs is increased cost certainty in both the development and operation of these systems while still allowing industry to be innovative. In this arrangement, NASA's role is to provide a customer base to kick off the market and to offer knowledgeable oversight to both companies, assuring astronaut and payload safety and meeting the national goals of utilizing America's space laboratory. During the panel, Kathy Lueders of NASA's Commercial Crew Program, John Mulholland of The Boeing Company, and Garrett Reisman of SpaceX talked about the government-industry partnerships, innovations and progress to-date.

John Mulholland spoke about Boeing's CST-100 Starliner, the commercial crew and cargo processing facility, Space Launch Complex-41, and Atlas V – 100th launch. In closing he spoke to what is next. For 2015-16, there should be completion of the crew access tower, parachute drop testing, the hot fire test, build-up of the qualification test vehicle, and build-up of the flight test vehicle. For 2017, there is the pad abort, the first uncrewed flight, the first crewed flight and certification (Mulholland, 2015).

Garrett Reisman spoke about the SpaceX Commercial Space Crew Program. SpaceX is developing a complete, safe, and reliable Crew Transportation System with the Crew Dragon vehicle, the Falcon 9 launch vehicle, and the ground launch system. In other words, SpaceX is going to manage all operations from crew, to launch, to mission, to ground and to recovery. System highlights include the following: (1) Dragon carries up to 7 crew members, or 4-5 crew members plus cargo bags and powered lockers; (2) Dragon has a state-of-the-art integrated abort system; (3) SpaceX crew missions will launch from the fully upgraded historic Pad 39A; (4) Dragon is designed for propulsive landing and rapid reusability – primary certification for parachute-to-water landing and new Dragons each mission; and (5) Dragon is capable of a 210-day stay on the ISS. Flights are as follows: (1) Demo-1 to ISS, without crew; (2) In-Flight Abort Test; (3) Demo-2 to ISS, with crew; and (4) Up to 6 Post Certification Missions (PCMs). He assured the audience that SpaceX is on schedule to restore US crew-carrying capability by 2017 (Reisman, 2015).

Next, Reisman spoke about milestone status. Recent completions include the certification baseline review in December 2014, the Pad Abort Test in May 2015, and the Avionics Test Bed Activation in June 2015. Major 2015 milestones included the critical design review, the docking system qualification, the launch site operational readiness (LSORR), the initial propulsion module testing, and the propulsive land landing testing. Major 2016 milestones will include LSORR for crew, ECLSS integrated test, validation propulsion module testing, space suit qualification, and demo 1 autonomous flight to the ISS. Major 2017 milestones will include completion of parachute qualification, design certification review, certification review, in-flight abort test, and demo 2 flight to the ISS with crew (Reisman, 2015).

Topic 18: Leveraging Supplier Pedigree and Technology for Commercial Space

Jason Best, Key Account Manager, Aerospace and Defense at Stellar Technology, LORD Corporation, gave this spotlight talk.

LORD Corporation

Stellar Technology, a business unit of Lord Corporation, is the leading provider of pressure sensors, temperature sensors, and force sensors for the rapidly expanding global commercial space market. Stellar Technology sensors are specified for a broad range of commercial space applications including: ground support systems, propulsion systems, launch vehicles, environmental control and life support systems, flight control systems, thruster/reaction control systems, recovery systems, and component testing. Customers select Stellar Technology transducers and transmitters because of the premium placed on safety, reliability, efficiency, and cost (Stellar Technology, 2015).

Stellar Technology pressure transducers, temperature transmitters, load cells, torque cells, displacement sensors, and instrumentation provide applications solutions for many of the diverse activities associated with private and federal space programs. Some of these programs include: (1) Launching Crew and Cargo to the ISS; (2) Commercial Orbital Transportation Services (COTS); (3) Space Tourism; (4) Suborbital Hypersonic Point-to-Point Travel; (5) NASA's Commercial Crew Development Program (CCDev2); (6) Micro-Satellite Propulsion Systems; (7) On-Orbit Fuel Depots/Cryogenic Propellant Transfer Systems; (8) Scientific Research; (9) Education and Training Programs; (10) Astronaut Training; and (11) National Security Application. Stellar Technology is a US company with engineering, manufacturing, and service facilities in Amherst, New York, and regional technical sales offices throughout the US (Stellar Technology, 2015).

Key Account Manager, Aerospace and Defense, Stellar Technology: Jason Best

Mr. Best is Key Account Manager, Aerospace and Defense at Stellar Technology Sensors, a division of LORD Corporation. Jason received his Bachelor of Science degree in Electrical Engineering from the University of Utah. He worked as an operational flight instrumentation design engineer on the Space Shuttle Reusable Solid Rocket Motor (RSRM) program, where he helped develop and maintain supplier engineering and business relationships from post-Columbia, return-to-flight objectives through end-of-program procurement milestones. He worked on the NASA Ares I First Stage Avionics and Operational Flight Instrumentation systems, where he helped develop solutions to improve crew safety through sensing key first stage motor performance parameters as input to crew launch abort criteria. Jason presently works with a variety of space companies in the traditional NASA space programs, the defense launch industry, and the commercial space community to develop and implement sensor design solutions for pressure, temperature, load, torque, and displacement measurement, matching the technical needs of customer applications with their defined cost structure and varied procurement systems (ISPCS Speaker Biographies, 2015cc).

Leveraging Supplier Pedigree and Technology for Commercial Space

The historical investments in technology and process improvements by DoD, NASA, Commercial Aircraft, and cross-industry sources to achieve high-reliability components and systems reside within supplier companies. Commercial space companies can access this pedigree and technology without the required costs to develop these components and systems initially. Strategic partnerships between commercial space companies and key suppliers can result in further commercialization of investments from NASA and industry sources, which should serve to reduce the total mission cost to commercial space companies. Trends in commercial space indicate more in-house component and system development due to perceived reduction in cost and control of production constraints. What does the commercial space industry stand to lose if this approach is adopted? How do suppliers and commercial space companies establish and improve partnerships to achieve space reliability components at commercial price and schedule expectations?

Jason Best spoke about the premise that the pedigree and lessons learned from the investments of previous generations of NASA and DoD programs resides within the historical space supply base. The industry must balance component cost, schedule control, and design autonomy with supplier design pedigree, lessons learned, and cross-industry knowledge. Best asked what made it possible, and answered with: investing in commercial space, investing in suppliers, requirement management, and strategic relationships. Suppliers make a difference in these ways: (1) by leveraging strategic suppliers in this industry; (2) by capturing the investments of previous space generations; and (3) by utilizing supplier pedigree and lessons learned to reduce cost and improve mission reliability (Best, 2015).

Topic 19: Virgin Galactic: Entrepreneurship and the New Space Economy

George T. Whitesides, the CEO of Virgin Galactic, gave this keynote address.

Virgin Galactic (see above)

CEO: George T. Whitesides

George T. Whitesides is the CEO of Virgin Galactic, the spaceflight company founded by Sir Richard Branson. In his role, George is responsible for guiding all aspects of the company to commercial operation at Spaceport America in New Mexico. Prior to Virgin Galactic, George served as NASA's Chief of Staff. George is a board member for Virgin Unite USA, the philanthropic organization of Virgin Group, a member of the World Economic Forum's Global Agenda Council on Space Security, and a fellow of the Royal Aeronautical Society. He and his wife Loretta have two children and live in Lancaster, California (ISPCS Speaker Biographies, 2015dd).

Virgin Galactic: Entrepreneurship and the New Space Economy

Virgin Galactic will be Earth's first spaceline, aiming to open access to space for new human and satellite customers. Virgin Galactic CEO, George T. Whitesides, shared his views on the economic opportunities for space and the latest progress of SpaceShipTwo, which will take private citizens to space, and the development of launch services through LauncherOne.

Whitesides started the talk by noting how few people have been to space – 551 to be exact! He spoke about SpaceShipTwo and LauncherOne. He said that the world's leading satellite inventors deserve a launch vehicle that works the way their satellites work. That is why LauncherOne was built to support quick, responsive, and affordable cubesat and microsatellite missions. LauncherOne has been designed from the start to be affordable, reliable, flexible, and responsive. They accomplish those ambitious goals through the way they design the system, the way they build it, and way they operate it. One critically important aspect of their method is the way they launch the system. Rather than launching from a traditional launch pad at a spaceport, LauncherOne is launched from a dedicated carrier aircraft, at an altitude of approximately 35,000 feet. Starting each mission with an airplane rather than a traditional launch pad offers performance benefits in terms of payload capacity, but more importantly, air-launch offers an unparalleled level of flexibility. LauncherOne will operate from a variety of locations independently of traditional launch ranges, which are often congested with traffic, and will have the ability to operate through or, around a variety of weather conditions and other impediments that delay traditional launches (Virgin Galactic, 2015b).

Once released from the carrier aircraft, the LauncherOne rocket fires up its single main stage engine, a 73,500lbf, LOX/RP-1 rocket engine called the NewtonThree. Typically, this engine would fire for approximately three minutes. After stage separation, the single upper stage engine, a 5,000lbf LOX/RP-1 rocket engine called the NewtonFour would carry the satellite(s) into orbit. Typically, the second stage would execute multiple burns totaling nearly six minutes. Both the NewtonThree and the NewtonFour are highly reliable liquid rocket engines designed, tested, and built by Virgin Galactic. At the end of this sequence, LauncherOne would deploy their customers' satellite (or satellites) into their desired orbit. Both stages of LauncherOne would be safely deorbited, while the carrier aircraft would return to a predetermined airport, where it could be quickly prepared for its next flight (Virgin Galactic, 2015b).

Whitesides continued with some more updates. They have made great strides in developing LauncherOne since beginning work in earnest in mid-2012. With development being led by a dedicated team of more than 150 experienced professionals, the LauncherOne team has already conducted extensive component-level testing of the vehicle's key systems, including the vehicle's first and second stage liquid rocket engines, composite tanks, avionics, and others. Earlier, the LauncherOne program moved into a new, 150,000 square foot manufacturing facility in Long Beach, California, which will be the home to the remainder of LauncherOne's development program as well as on-going manufacturing of launch vehicles (Virgin Galactic, 2015c).

Whitesides mentioned that their customers had consistently asked them for more performance. When they announced the LauncherOne program, the small satellite market was still quite new and unproven. In the time since, the market has expanded to include many more satellite manufacturers and operators. Some of the satellite innovators are designing satellites larger than they had originally planned; other companies are seeking to launch multiple satellites at the same time. When they initially announced LauncherOne, they pledged that customers would be able to launch approximately 120 kg to a standard Sun-Synchronous Orbit for less than $10 million. Now, they are proud to offer customers the ability to launch 200 kg to the same orbit for that same amount (Virgin Galactic, 2015c).

Whitesides announced that the LauncherOne team has been making steady progress on all of the key components of their dedicated small satellite launch vehicle

LauncherOne at their custom-built test stands in Mojave. He showed video to demonstrate the latest successful test firing of the NewtonThree main stage engine, which ran for more than 20 seconds. The test reached steady-state operation and allowed the team to capture high quality data about the engine during start-up, operation, and safe shutdown. It occurred the same week as multiple full duration firings of the gas generator for LauncherOne's upper stage engine, each exceeding six minutes in duration (Virgin Galactic, 2015d).

He also talked about Virgin Galactic outreach in New Mexico. With respect to local education, Virgin Galactic is involved with Las Cruces Public Schools, Las Cruces Challenger Center, Tombaugh Elementary School, Las Cruces Academy, Truth or Consequences Schools, Pecos Valley Schools, and NMSU. With respect to the local community, Virgin Galactic is involved with Big Brothers Big Sisters (Mountain Region), ISPCS, NM Space Grant Consortium, EAA Chapter 51, Girl Scouts, Boy Scouts, YPO NM/West Texas Chapters, and other local stakeholders. With respect to New Mexico (NM) State, Virgin Galactic is involved with NM Tourism Department, Albuquerque Chamber of Commerce, NM Society of Professional Engineers, and Spaceport America/Spaceport Authority support. With respect to Virgin Galactic Gateway to space, the company is involved with Open House, Pilot Fly In support, Tour support, and Movie shoots. With respect to national/international outreach, Virgin Galactic is involved with Galactic Unite Grants Program, School Video Hangouts, Future Travel Experience, JLR 4x4 Schools Competition, and Google Science Fair (Whitesides, 2015).

Topic 20: The SPACE Act and the Evolving Commercial Space Industry

Will Pomerantz, Vice President for Special Projects at Virgin Galactic stood in for Stuart Witt, CEO and General Manager at the Mojave Air and Space Port, who was unable to attend the conference, and gave this spotlight talk.

Mojave Air and Space Port

Mojave Air and Space Port emerged as the leading aerospace test center for commercial operations in North America. No longer a sleepy high desert general aviation Mojave Airport destination, Mojave Air and Space Port has amassed more first flights and significant newsworthy flight activity than any other airport in the world over the past ten years. Currently it is home to more than 60 companies engaged in flight development to light industrial to highly advanced aerospace design, flight test and research and even heavy rail industrial manufacturing (Mojave Air and Space Port, 2015).

Over the past ten years they have upgraded infrastructure, added 3,000 feet of runway and integrated a new commercial development taxiway system. Aerospace and Industry are flocking to the High Desert and specifically to Mojave airport to design, test and produce tomorrow's leading edge products. The wind industry and aviation industry rely heavily on composite fabrication utilizing carbon fiber and fiberglass technology, both resident at Mojave Air and Space Port through a network of design, fabrication and testing firms. The commercial aircraft industry relies heavily on firms located at Mojave Airport to perform aircraft inspections, storage and part-out. Many specialty firms at Mojave focus specifically on engine development, noise reduction technology, advanced cockpit display development and major airframe design modifications. Mojave

Air and Space Port is home to the National Test Pilot School, accredited in 2006, where more test pilots are educated than any other site in the world. Flight research activities include endo- and exo-atmospheric craft supporting private sector and government-funded projects. In 2004, Mojave Spaceport hosted the Ansari XPrize suborbital space flights. The only Americans to reach space in 2004 in a US craft did so from Mojave Spaceport (Mojave Air and Space Port, 2015).

Their upgraded rail infrastructure and switch engine moves product in and out of Mojave Air and Space Port with 34 daily rail car shipments through a license agreement with Union Pacific. Three companies operate on their rail spur moving raw product onto the airport and manufactured product out. They completed a precise development plan in 2006 along with three fence-to-fence environmental assessments (Mojave Air and Space Port, 2015).

CEO and General Manager: Stuart Witt

Stuart was born and raised on Scodie Ranch in the small central California town of Onyx and attended K12 school in Isabella graduating in 1970. He is a 1974 graduate of California State University Northridge, Naval Aviation Schools Command 1976, designated a Naval Aviator in 1977, Naval Fighter Weapons School graduate (TOPGUN) 1980, and 1996 graduate of the University of Maryland's Center for Creative Leadership. His military career took him to sea on USS JFK as a carrier based F-14 Tomcat pilot, then as an FA-18A Hornet project pilot at the Naval Air Warfare Center, China Lake California and as a Naval Reserve officer flying RF8C Crusaders and FA18 Hornets from 1985 to 1993. Between 1985 and 1993 Stuart served as an Engineering Test Pilot on the B-1B, F-16C and F-23 with Westinghouse Electric Corp. From 1993 to 2002 he served as Executive Vice President of CTA Inc., where he directed engineering projects from Lower Manhattan to Oahu. Bottom line, Stuart is a 44-year veteran of the aerospace industry with extensive operational, research and development, project through executive management and leadership and continues to be a forward leaning force for commercial space as a nationally recognized executive leader in the field (ISPCS Speaker Biographies, 2015ee).

For the past 11 years or so he has been directing the expansion efforts of the Mojave Air and Space Port. In 2004, Mojave was designated the nation’s first inland spaceport and played host to the world as Scaled Composites qualified and won the $10M Ansari XPrize giving birth to the commercial manned spaceflight industry. Stuart is a founding executive member of the Commercial Spaceflight Federation and currently serves as Board Chairman. Additionally, Stuart is a sitting Trustee and former chairman on the Kern Community College Board. Most recently, Stuart is credited with crafting and seeing through to Governor Brown’s signature new Space Participant Liability reform in California known as AB2243 and is currently the leading force behind SB415 (ISPCS Speaker Biographies, 2015ee).

Stuart is credited with expanding the employment base of a remote California “Aerospace Valley” airport into the nation’s leading civilian aerospace test center and galvanized hub of the commercial space industry research and development. Over the past 11 years, the Mojave Air and Space Port has grown from over 400 full time equivalent professional jobs with 14 firms to 79 firms and 2,500 full time professional aviation and industrial jobs in a remote location, in aerospace, and in a declining economy (ISPCS Speaker Biographies, 2015ee).

Expansion came in largely from private investors of ‘high net worth’ in the form of rail, soft tire, air and industrial as Mojave diversified its revenue base and became the model for how general aviation airports could achieve self-reliance and grow to meet the business needs of their respective communities without sacrificing operations due to encroachment (ISPCS Speaker Biographies, 2015ee).

An avid outdoorsman, hunter, fisherman, alpine skier, and naturalist, he seeks a balance between individual rights and wildlife management. He has been the focus of numerous televised infomercials on aerospace and has presented a TEDx talk on the skewed balance between western society’s obsession with “Risk Adversity and Humanities need to Explore.” Stuart’s strong belief of personal integrity, individual responsibility and honoring commitments while exceeding expectations have been published by numerous syndicated columnists, worldwide. An accomplished public speaker, Stuart commits to an average 25 public speaking events annually, both domestic and internationally on the subjects of “Permission” and “Risk versus Exploration” and their relation to the future of aerospace. As he points out, “You can see the future from Mojave” (ISPCS Speaker Biographies, 2015ee).

The Space Act and the Evolving Commercial Space Industry

Recently, the Bipartisan Spurring Private Aerospace Competitiveness and Entrepreneurship Act (SPACE Act of 2015) passed by a large majority in the US House of Representatives. Stuart Witt was supposed to address the major policy issues and the implications of the SPACE Act, which impact the future of the industry’s evolution, but was unable to attend the conference. Therefore, this author, being an attorney has taken it upon herself to brief you on this matter.

This House Resolution (H.R.) 2262 passed the House of Representatives on May 21, 2015 and is now in the hands of the Senate awaiting passage and then a sign off by the US President before becoming law. This is an act to facilitate a pro-growth environment for the developing commercial space industry by encouraging private sector investment and creating more stable and predictable regulatory conditions, and for other purposes (Library of Congress, 2015). This act seeks to amend some sections of Chapter 509 of Title 51 of the United States Code (USC), as well as add some new text. But first, some background so you can place this in context.

51 USC Subtitle V, Chapter 509 authorizes the Secretary of Transportation and, through delegations, the Federal Aviation Administration (FAA) Associate Administrator for Commercial Space Transportation, to oversee, license, and regulate both launches and reentries, and the operation of launch and reentry sites when carried out by US citizens or within the US. Chapter 509 directs the FAA to exercise this responsibility consistent with public health and safety, safety of property, and the national security and foreign policy interests of the US, and to encourage, facilitate, and promote commercial space launch and reentry by the private sector (FAA, 2011).

The Commercial Space Launch Amendments Act (CSLAA) of 2004 assigned the FAA the responsibility for regulating commercial human space flight. In December 2006, the FAA issued human space flight regulations in accordance with its authority to protect public health and safety. The CSLAA prohibited the FAA from proposing regulations governing the design or operation of a launch vehicle to protect the health and safety of crew and space flight participants until December 23, 2012, or until a design feature or operating practice had resulted in a serious or fatal injury, or contributed to an event that posed a high risk of causing a death or serious injury, to crew or space flight participants during a licensed or permitted commercial human space flight (FAA, 2011). This deadline was since extended to October 2015 (Space Politics, 2013).

Until such time, the CSLAA only requires that a space flight participant be informed of the risks of taking a ride on a rocket. The FAA may also issue regulations setting reasonable requirements for space flight participants, including medical and training requirements. Because of recent changes in US policy and the effect they have had on the commercial space transportation industry, the FAA is planning to propose regulations to protect the health and safety of crew and space flight participants for orbital human spaceflight as soon as circumstances require after October 2015 (Space Politics, 2013).

The FAA believes it is important to establish a regulatory foundation as early as possible to provide industry assurance that systems built to support NASA's missions will be compatible with future FAA regulations. The CSLAA mandates that any regulations governing the design or operation of a launch vehicle to protect the health and safety of crew and space flight participants must take into consideration the evolving standards of safety in the commercial space flight industry. When developed, the proposed regulations are planned to be a starting point for a regulatory regime that will evolve over time as the industry matures. Moreover, in order to facilitate the development of a successful commercial human space transportation industry, the FAA and NASA must develop complementary safety regimes for orbital human space flight (FAA, 2011). As noted throughout this paper, NASA has already begun to develop requirements for its procurement of orbital transport services.

So, with this background in mind, here is what this HR 2262 proposes. The short title of this Act may be cited as the “Spurring Private Aerospace Competitiveness and Entrepreneurship Act of 2015”, or briefly “SPACE Act of 2015.” With respect to Title I – Commercial Space Launch, Section 101, Consensus Standards, it proposes to amend Section 50905(c) of Title 51 USC, by striking through some text and adding an Interim Industry Voluntary Consensus Standards Report, with updates due by December 2016, 2018, 2020, and 2022 respectively. The Act also adds an Interim Report on Knowledge and Operational Experience, with updates due by December 2016, 2018, 2020, and 2022 respectively. Next, an Independent Review is due no later than December 2023. A Learning Period beginning in December 2025 is being proposed to develop regulations. Finally, it adds text discussing communication and transparency (Library of Congress, 2015).

With respect to Section 102, International Launch Competitiveness, it adds sections entitled: Purpose; Maximum Probable Loss Plan; Independent Assessment; and Launch Liability Extension. With respect to Section 103, Launch License Flexibility, it proposes to amend Section 50906 of Title 51 USC. With respect to Section 104, Government Astronauts, it proposes to amend the definitions of various terms such as government astronauts. It also amends Restrictions on Launches, Operations, and Reentries; Single License or Permit, as well as License Applications and Requirements; Applications. It amends Monitoring Activities and Additional Suspensions. With respect to Section 105, Indemnification for Space Flight Participants, it makes an amendment. With respect to Section 106, Independent Study of Indemnification for Space Flight Participants, the act requires a study to be conducted not later than one year after the date of enactment of this Act. With respect to Section 107, Federal Jurisdiction, the Act adds the following text. “Any action or tort arising from a licensed launch or reentry shall be the sole jurisdiction of the Federal courts” (Library of Congress, 2015, p.16).

With respect to Section 108, Cross-Waivers, it adds text to allow the licensee or transferee to make a reciprocal waiver of claims with its contractors, subcontractors, and customers. With respect to Section 109, Orbital Traffic Management, the Act addresses the sense of Congress as to space traffic management to minimize the proliferation of debris and decrease the congestion of the orbital environment. To this end, it requires a study to be started no later than 90 days after the date of enactment of this Act with an independent, nonprofit, private systems engineering and technical assistance organization. With respect to Section 110, State Commercial Launch Facilities, the Act addresses the sense of Congress as to State involvement, development, ownership, and operation of launch facilities to help enable growth of the Nation’s commercial suborbital and orbital space endeavors and support both commercial and government space programs. To this end, it requires a report to be sent no later than one year after the date of enactment of this Act by the Comptroller General to the Committee on Science, Space, and Technology of the House and the Committee on Commerce, Science, and Transportation of the Senate (Library of Congress, 2015).

With respect to Section 111, Space Support Vehicles Study, not less than one year after the date of enactment of this Act, the Comptroller General shall submit a study to the Committee on Science, Space, and Technology of the House and the Committee on Commerce, Science, and Transportation of the Senate. With respect to Section 112, Streamline Commercial Space Launch Activities, it is the sense of Congress that eliminating duplicative requirements and approvals for commercial launch and reentry operations will promote and encourage the development of the commercial space sector. With respect to Section 113, Space Launch System Update, the Act replaces the words, ‘Space Shuttle’ with ‘Space Launch System’ (Library of Congress, 2015).

With respect to Title II – Space Resource Exploration and Utilization, a number of sections shall be added to Chapter 513. Section 51301 definitions shall include the following: space resource; asteroid resource; State; and US Commercial Space Resource Utilization Entity. Section 51302 will describe the commercialization of space resource exploration and utilization. Section 51303 will describe the legal framework pertaining to property rights, civil action for relief from harmful interference, rule of decision, and exclusive jurisdiction. With respect to Title III – Commercial Remote Sensing, Section 301 will require annual reporting and Section 302 will require a statutory update report. Title IV – Office of Space Commerce adds some more sections. Section 401 amends the word ‘Commercialization’ to ‘Commerce’ in the title. Section 402 outlines the functions of the Office of Space Commerce (Library of Congress, 2015).

Topic 21: Commercial Space: The View from an Entrepreneur and a Venture Capitalist

Tom Ingersoll, Space Entrepreneur and former CEO of Skybox Imaging, and Sunil Nagaraj, Vice President at Bessemer Venture Partners, jointly discussed this topic in their panel.

Skybox Imaging

In today's connected world, every organization is deeply impacted by events across the globe on a daily basis. Skybox Imaging was founded on the premise that an ability to better understand these phenomena could fundamentally change the way humanity makes decisions on a daily basis thereby increasing the profitability of businesses and improving the welfare of societies worldwide. Skybox Imaging builds satellites, they write code, and they deploy data centers. But at heart Skybox is about unlocking the human story by approaching daily global activity as the world's largest data science problem (Skybox Imaging, 2015).

The company calls this Earth Observation 2.0, where satellites are simply sensors and the magic is in harnessing scalable computing and unbounded analytics to find answers to the world's most important geospatial problems regardless of data source. At Skybox, technology is a means to an end. The company does not design and build their systems for fun, although they think it is. They do it because it gives them the flexibility to address their customers' needs in the way that works best for them and their organization. Skybox Imaging satellites and software are constantly evolving to better serve their customers (Skybox Imaging, 2015).

In 2009, the founders wrote the first Skybox business plan as part of a Stanford graduate entrepreneurship course. They spent six months working out of John Fenwick's living room. They secured Series A financing of $3M from Khosla Ventures. Next, they moved into a windowless 3,000 square feet office in Palo Alto, and soon began to attract, court, and hire the smartest people they knew to join the vision. In 2010, they began designing data platform and high-resolution imaging satellites, and began expanding their network of customers, partners, and suppliers. Soon they moved to Mountain View and began building their manufacturing facility. In 2011, they completed Series B financing of $18M from Khosla Ventures and Bessemer Venture Partners. Meanwhile, they designed scalable data infrastructure, and completed satellite Critical Design Review for SkySat-1 and SkySat-2. They began building their mission control team and hired their new CEO, Tom Ingersoll. In 2012, they completed Series C financing of $70M from Canaan Partners, Norwest Venture Partners, Khosla Ventures, and Bessemer Venture Partners. They also completed proprietary image processing toolbox and tasking and scheduling algorithms. They deployed remote ground stations around the world, and completed design and fabrication of SkySat-1 as well as began building SkySat-2. Next, they partnered with ECAPS on propulsion module for SkySat-3 and beyond. In 2013, Skybox Imaging announced a partnership with Japan Space Imaging, a subsidiary of Mitsubishi. They completed design, manufacture, and test of the first two spacecraft, SkySat-1 and SkySat-2 at Skybox HQ. They also completed mission operations and production infrastructure to fly their constellation via Chrome. By this time the company had reached 100 employees. By 2014, Skybox Imaging had been acquired by Google. Also, they successfully launched SkySat-2 aboard a Soyuz-2/Fregat rocket, and bought an Orbital Sciences Minotaur-C rocket to launch six additional SkySats out of Vandenberg Air Force Base in 2015. By now the company had reached 125 employees (Skybox Imaging, 2015).

Space Entrepreneur and Former CEO of Skybox Imaging: Tom Ingersoll

Tom Ingersoll is an aerospace veteran and entrepreneur with more than 25 years of experience in the space and communications industry. Most recently he was the CEO of Skybox Imaging, leading it from early development through launch of 2 high-resolution imaging satellites and its purchase by Google (ISPCS Speaker Biographies, 2015ff).

Previously he was cofounder and CEO with Charles “Pete” Conrad of Universal Space Network (USN), a leading provider of global ground station services to the satellite industry. He started his career in the Phantomworks of McDonnell Douglas Corporation where he served as deputy flight manager and then program manager for the Delta Clipper Experimental (DC-X) reusable launch system. He has worked extensively with the venture and private equity communities raising more than $130M for commercial space ventures with multiple successful exit events. Tom has a Bachelor of Science degree in mechanical engineering with honors and a Masters of Science degree in engineering management, both from Brigham Young University. In his spare time, Tom enjoys spending time with his family along with road and mountain biking (ISPCS Speaker Biographies, 2015ff).

Bessemer Venture Partners (BVP)

In 1872, Henry Phipps, Jr. and Andrew Carnegie co-founded Carnegie Steel, an innovative steel producer that commercialized an industrial process licensed from Lord Henry Bessemer. When they sold their startup 29 years later, Henry formed a family office to re-invest his proceeds into other entrepreneurial ventures like his own. He adopted the Bessemer name to honor the inventor behind his startup's success (BVP, 2015).

A century later, BVP continues one of the longest-running records of success in the venture capital industry. Over the course of its history, investors at the firm formed or funded over 100 startups that grew into independent public companies. They provided seed funding for early industrial companies like WR Grace, Ingersoll Rand and International Paper, retail innovators like Staples, The Sports Authority and Blue Nile, new drug developers like Isis and Perseptive Biosystems, service pioneers like Gartner Group, Bright Horizons and Celtel, and high-tech innovators like Ciena, Parametric, VMX, DSP Group (now Intel), Maxim, Flarion (now Qualcomm), Skype, and LinkedIn (BVP, 2015).

Today, BVP has offices in New York, Silicon Valley, Boston, Bangalore and Herzliya and manages more than $4 billion of venture capital invested in over 160 companies around the world. BVP focuses investment activity around several well-developed thematic ‘roadmaps’, seeking out entrepreneurial opportunities that align with these themes across a wide mix of industries, geographies, and stages - many of their portfolio companies, like Ungermann Bass and Verisign, have been incubated in their offices based on ideas arising from these roadmaps (BVP, 2015).

Beyond roadmap investing, the everyday priority of BVP professionals is applying their startup experience to support the entrepreneurs they back. Since 2010, Bessemer Venture Partners has realized eleven IPOs including Cornerstone, Broadsoft, LinkedIn, Yelp, Millennial Media, Eloqua and LifeLock and multiple major acquisitions of companies in their portfolio (IAG by Nielsen, Sirtris by Glaxo, Gracenote by Sony, Bladelogic by BMC, PA Semi by Apple, Pure Networks by Cisco, Storwize by IBM, Vertica by HP, and Endeca by Oracle to name a few).

Vice President: Sunil Nagaraj

Sunil, a Vice President in the Menlo Park, CA office, focuses on investments in space, developer tools, and security companies. Sunil serves as a Board Director for Auth0 and Nitrous.IO. He is a board observer at GetInsured, Rocket Lab, and Virtru. Sunil is also closely involved with Bessemer's investments in Box, DocuSign, Simply Measured, Tile and Zapier. His past investments include Twitch (acquired by Amazon), Defense.net (acquired by F5 Networks) and Grow Mobile (acquired by Perion) (ISPCS Speaker Biographies, 2015gg).

Prior to joining Bessemer, Sunil was the founder and CEO of Triangulate, a venture-backed online dating startup that used social media behaviors to drive algorithmic matching. Previously, Sunil worked in consulting at Bain & Company, in Cisco's Corporate Development group, and in product management at Microsoft. He has also worked at several early-stage startups (Sendio, ZeeWise, Celito) as a software engineer and in business development. Sunil frequently speaks about best practices for growing startups (ISPCS Speaker Biographies, 2015gg).

Sunil holds an MBA from Harvard Business School and a Bachelor of Science degree in Computer Science from the University of North Carolina at Chapel Hill, where he graduated with honors. Sunil is Co-Founder/Co-Chair of the NextGen Board of the Computer History Museum and is Co-Chair of NextGen Partners, the largest pre-partner VC networking group in the Bay Area. He also serves on the board of the San Francisco Amateur Astronomers. In his free time, Sunil enjoys sailing and stargazing (ISPCS Speaker Biographies, 2015gg).

Commercial Space: The View from an Entrepreneur and a Venture Capitalist

As CEO of Skybox Imaging, Tom Ingersoll grew the company from concept phase through launch of its first two satellites including a sale of the company to Google for $500M. Prior to that he co-founded Universal Space Network, which was acquired by Swedish Space Corporation in 2008. He offered his perspective on running venture backed space companies and being acquired by mainstream technology companies. Sunil Nagaraj, a venture capitalist with Bessemer Venture Partners, shared his thoughts on investing in commercial space including what he looks for in prospective investments. Bessemer has invested in Skybox Imaging, Rocket Lab, and Spire.

Topic 22: Spaceport America’s Other Business

Garrett C. Hill, CEO at X2nSat, gave this spotlight talk.

X2nSat

X2nSat is one of the most veteran Very Small Aperture Terminals (VSAT) providers in North America; extending their customers’ reach anywhere they do business for over 15 years. Founded with a mission to provide highly reliable, wireless network and communication solutions to a wide variety of industries, they are proud to provide the robust services of a large telecomm with the personalized customer care of a specialty organization (X2nSat, 2105).

When they utilize any X2nSat service, from their extensive catalogue of Enterprise Solutions to their Managed Services and Engineering Consultation, they are much more than a passive third party contractor, they are the satellite communications arm of their customers' organization, committed to superior service. With a state-of-the-art, high-capacity satellite teleport site and a 24x7x365 Network Operations Center located in California and redundant teleports and data centers spread throughout the US, X2nSat has the capacity to deliver extremely secure network solutions and services anywhere their customers work (X2nSat, 2105).

CEO: Garrett C. Hill

In 1996, Garrett C. Hill founded X2nSat with a mission to provide highly reliable, wireless network and communication solutions to a variety of industries around the globe. He passionately believes in X2nSat's vision to build the infrastructure for the next generation of satellite communications, and drives a company culture that embraces collaboration and creativity (ISPCS Speaker Biographies, 2015hh).

Under Mr. Hill's leadership, X2nSat has assembled the best team in the Very Small Aperture Terminal (VSAT) industry and successfully launched satellite-based communication network solutions for emergency communications, disaster recovery, enterprise, information technology, telemedicine, rural telephony, maritime, utility, government, and other mission-critical organizations and applications. With existing satellite gateway teleports located on both coasts, X2nSat recently announced its plans to build a third satellite gateway at the world's first purpose-built, commercial spaceport – Spaceport America in New Mexico (ISPCS Speaker Biographies, 2015hh).

Early in his career, Mr. Hill designed and helped build the first trans-Pacific satellite network to transport TCP/IP. This moment in history was pivotal in introducing the world beyond the US borders to the Internet. He was on the ground floor as an integral contributor to what became known as Telecom Valley in Petaluma, California, in the North San Francisco Bay Area, and in 2005, he pioneered the first satellite-based network technology providing voice and high-speed data in a regulated phone environment to rural America, under the auspices of the USDA's Rural Utilities Service. Mr. Hill serves on several corporate boards of directors, including the boards of X2nSat, Todocast, and IP Access. He lives in Petaluma, California, with his wife and two daughters. He is an active member of Rotary International (ISPCS Speaker Biographies, 2015hh).

Spaceport America's Other Business

Garrett Hill discussed his vision for the space community located at Spaceport America, as well as how X2nSat intends to capitalize on space technology to achieve a world that is connected, green, safe, and prosperous. His discussion began with a review of some of the latest uses of VSAT technology that accomplish these goals. The conversation transitioned into a focus on the latest technology and ideas that will be incorporated into the design and construction of the new, state-of-the-art facility being built at Spaceport America. X2nSat's facility will incorporate anticipated designs for satellites not yet launched and building practices that represent the values of X2nSat and its commitment to leaving a small footprint on the Earth. Although construction has not yet begun and plans are subject to adjustment, Mr. Hill shared the latest information available for the 20-year plan for X2nSat's Spaceport America location.

According to Hill, the project status is as follows. By 2015, the goal is to finalize the Land Lease Agreement, complete architectural plans, and complete engineering documents. By 2016, the plan is to build utilities to site, construct the main building, and install the first two antennas (Hill, 2015).

Topic 23: AirStrato UAS, the Financial Tool for ARCA's Space Business Development

Dumitru Popescu, President of ARCA Space Corporation, gave this spotlight talk.

ARCA Space Corporation

ARCA Space is a for-profit US corporation and its main objective is the exploration of space. In order to reach this objective, ARCA builds and launches the most cost effective space vehicles. They are using technologies already existent, in an innovative way that allows access to space on a large scale by reducing financial constraints. They want to accomplish this because they strongly believe that the future of mankind is linked to the exploration of space (ARCA Space Corporation, 2015).

ARCA was established as a non-government organization in 1999 in Romania, European Union. They built and launched a series of aerospace vehicles that made ARCA one of the most well known organizations involved in the development of private space flight. In 2004, during the $10 million Ansari XPrize Competition, ARCA successfully launched its first rocket, Demonstrator 2B. In 2006, ARCA built the world's largest solar balloon that lifted into the stratosphere the crewb capsule of Stabilo, a manned suborbital vehicle created after the end of Ansari XPrize Competition. In 2007, the Stabilo program continued, this time with an even larger solar balloon lifting the complete Stabilo vehicle into the stratosphere. In 2008, ARCA joined the $30 million Google Lunar XPrize Competition and in 2013 the team withdrew from the Competition, their main activity focusing on other programs (ARCA Space Corporation, 2015).

In 2010, Helen rocket was launched at 120,000ft, the event representing the first powered flight in the Google Lunar XPrize Competition. The rocket was transported into the stratosphere with the help of an ARCA built helium balloon. In 2012, Haas rocket series was introduced, consisting of the sub-orbital Haas 2B and orbital Haas 2C rocket launchers. The development of these launchers is currently their main activity. In 2013, the European Space Agency (ESA) awarded ARCA with a contract to test the parachute system for the ExoMars spacecraft that will be launched to Mars in 2016. ARCA also developed the hardware for the High Altitude Drop Test. In 2014, AirStrato 'The most amazing air robot in the world' performed the first flight at the beginning of 2015 and it was ARCA's first product to become commercially available. In 2014, ARCA center of operations moved from the European Union into the US and ARCA Space Corporation, with headquarters in Las Cruces, New Mexico, was established (ARCA Space Corporation, 2015).

President: Dumitru Popescu

Dumitru studied Aerospace Engineering at Polytechnics University of Bucharest, Romania. In 1999, he founded ARCA, an aerospace non-governmental organization (NGO). He coordinated civilian rocket design and launches of ARCA NGO and led his team through both Ansari and Google Lunar XPrize Competitions (ISPCS Speaker Biographies, 2015ii).

He is currently the President and CEO of ARCA Space Corporation, a US based company, from Las Cruces, New Mexico. Among his achievements: (1) The launch of the Demonstrator 2B rocket, equipped with the world's first composite materials reusable rocket engine, event that took place in 2004, from Cape Midia Air Force Base, for the Ansari XPrize; (2) The flight test of Stabilo, a suborbital system that consisted of two flights: Mission 1, launched at an altitude of 48,500ft, into the stratosphere and Mission 2, launched in 2007 at an altitude of 39,600ft above the Black Sea; (3) The launch of Helen suborbital rocket, a technological demonstrator for the Google Lunar XPrize competition. The Mission 4B was launched from a Navy ship above the Black Sea in 2010, for the Google Lunar XPrize. The flight reached an altitude of 132,000ft; (4) The development of Executor, turbopump driven, 48,000lbs, liquid fueled rocket engine, utilizing LOX and kerosene; and (5) The development of Haas orbital and suborbital family of rockets (ISPCS Speaker Biographies, 2015ii).

AirStrato UAS, the Financial Tool for ARCA's Space Business Development

After the days of the Ansari XPrize, the world has learned that in order to build a space business, one needs to have one's own financial resources to draw from. The sponsors, the investors, or even the government contracts in the first stages of one's business, are not going to work. At least, not if you dream to build something big. And those people at ARCA Space Corporation have always dreamed big. Therefore they decided to create a more 'down to earth business' in order to further finance their space endeavor built around the Haas suborbital and orbital rocket series. This non-space related business is the AirStrato, high altitude, long endurance unmanned aerial system, that fills a huge gap between expensive, large military unmanned aerial vehicles and less expensive, small-scale civilian commercial drones by combining the performance of the former with the price of the latter.

AirStrato is bringing about a new era for aerial robotics with the introduction of AirStrato, an electrical powered aircraft able to fly almost twice as high as a commercial airliner. This product fills a huge gap between expensive, large, unmanned aerial military vehicles and less expensive small-scale commercial civilian drones by combining the performance of the former with the price of the latter. This will allow small-scale businesses, research institutions and even individuals to benefit from an affordable, high performance aerial robot. AirStrato can be controlled from any part of the world via satellite or GSM communication over the Internet; it can take off and land from any location, no matter how remote; it is very beautiful and most of all it is affordable. According to Popescu, when ARCA decided to create this aircraft they had only one goal in mind: to create a tool that will expand the human capabilities to explore and discover (AirStrato, 2015a).

The Explorer is a stratospheric flying robot designed to meet the highest expectations of an unmanned aerial vehicle. With a flight ceiling of 60,000ft (18,000m) using solar cells and internal batteries or 13,000ft (4,000m) using hybrid propulsion with a power generator and batteries, the Explorer can remain airborne for nearly a day. The ability to be controlled via satellite or GSM communication over the Internet makes the Explorer superior to other unmanned civilian aerial vehicles of the same price range. Its applications can include: border protection of land and sea, disaster monitoring and management, contaminated area monitoring, remote exploration of any geographic feature, rescue missions, reconnaissance, pipeline or power line inspection, communication relay, high atmospheric scientific research, meteorology, auto or maritime traffic control, TV and cinema recording, internet delivery network to remote areas, or strictly entertainment (AirStrato, 2015b).

The Pioneer is a slightly smaller version of the Explorer, designed to perform flights at lower altitudes. A 26,000ft (8,000m) flight ceiling, satellite control (with optional satellite communication device), and 12 hours of endurance using solar cells and batteries, or 13,000ft (4,000m) and 16 hours of endurance using hybrid propulsion with power generator and batteries, makes Pioneer a very competitive air-robot. Its applications can include are similar to those of the Explorer (AirStrato, 2015c).

In case people would want to launch the AirStrato robot from remote areas, where a runway is not available, the company created the accelerator. The Accelerator is a pneumatic launcher designed to allow both the Pioneer and Explorer to take off in less than a second from virtually any place on the planet. Since the AirStrato has an on-board recovery parachute, the aircraft can also land without a runway (AirStrato, 2015d).

The Interface is the mission control center. It is designed to communicate with all AirStrato models via satellite, no matter how far away you are from your aircraft. It allows you to view all flight parameters, to program the autopilot or to control the aircraft in assisted or in full manual mode. It also enables you to activate or deactivate sub-systems or to interact with your payload. It has a beautiful curved design that complements the AirStrato and Accelerator and is built entirely of composites (AirStrato, 2015e).

Topic 24: Doing Space Commercialization without the Pedigree

Rich Glover, CEO of Acme Advanced Materials, Inc., gave this spotlight talk.

Acme Advanced Materials, Inc.

ACME Advanced Materials, Inc. (A2M) was formed to exploit breakthrough technology that was developed and demonstrated by Masterson Industries, LLC. The Masterson merger with A2M was completed on January 27, 2014 and A2M is the sole surviving entity. A2M is the parent company to a family of wholly owned subsidiaries with each subsidiary established to further develop and commercialize unique A2M technologies. A2M is a privately owned corporation supported by funding from both US and International venture groups (ACME Advanced Materials, Inc., 2015).

CEO: Rich Glover

Rich Glover is the President and CEO of ACME Advanced Materials, Inc., a microgravity materials production company. ACME is funded by both international venture investors and US and is currently producing ultra-low defect, electrically superior silicon carbide wafers for the power electronics industry. ACME is 100%

commercially funded and has not received any funding or grants from the government. In 2012, Rich co-founded Masterson Industries to develop and demonstrate commercialization concepts for the high volume production of unique microgravity materials. The success of those demonstrations led to an acquisition by ACME in January 2014 (ISPCS Speaker Biographies, 2015jj).

Rich retired from the AF in 1998 and has worked for a number of both large and small aerospace contractors serving as Chief Engineer, Director of Operations, Director of Engineering, Division Manager and Vice President. He was also co-founder of Microgravity Enterprises which, in 2007, developed and sold the world's first space beer (Comet's Tail Amber Ale at Kelly's Brew Pub in Albuquerque) and space energy drink (Antimatter). The motto for ACME Advanced Materials is "sermo minor, operor magis" (ISPCS Speaker Biographies, 2015jj).

Doing Space Commercialization without the Pedigree

Suppose you are not a serial entrepreneur, you do not live in Silicon Valley, you are not independently wealthy and you are just happy to be able to pay your bills every month. How do you get the investment you need to turn your concept into a business? Rich Glover does not think there is a universal answer but his experience might be useful to help you plan your own venture. They have seen it all, lies, deception, delays, and rejection but in the end they have a good group of investors and are moving forward. He shared his history with the audience, warts and all, so that they could make their mistakes and not repeat his. Then, he had a few thoughts on where he sees space commercialization going over the next 100 years.

Topic 25: Turning Microgravity into a Billion Dollar Business

Rich Glover, CEO of Acme Advanced Materials, Inc., chaired this panel, which included Ioana Cozmuta, Microgravity Lead, Innovative Strategies Emerging Space Office/Space Portal Science and Technology Corporation, NASA Ames Research Center, and Dave Blivin, Managing Director, Cottonwood Technology Funds.

NASA Ames Research Center

NASA Ames Research Center, one of ten NASA field enters, is located in the heart of California's Silicon Valley, in Moffett Field. For more than 75 years, Ames has led NASA in conducting world-class research and development in aeronautics, exploration technology and science aligned with the center's core capabilities. Ames Research Center contributes to virtually every major NASA mission and initiative via their expertise in the following core areas: (1) Entry systems; (2) Supercomputing; (3) NextGen air transportation; (4) Airborne science; (5) Low-cost missions; (6) Biology and astrobiology; (7) Exoplanets; (8) Autonomy and robotics; (9) Lunar science; (10) Human systems integration; and (11) Wind tunnels. Ames is involved in the ISS, Journey to Mars, Earth Right Now, Technology, Aeronautics, and Solar System and Beyond (NASA Ames Research Center, 2015).

Microgravity Lead, Innovative Strategies Emerging Space Office/Space Portal Science and Technology Corporation: Dr. Ioana Cozmuta

Dr. Ioana Cozmuta is the Industry Innovation Lead at the Space Portal, NASA

Ames Research Center in Silicon Valley and the Microgravity Lead for the Emerging Space Office at NASA HQ providing fair broker technical, economic, market and business intelligence. She developed the innovative concepts of "Verticals of Microgravity" to translate and infuse microgravity driven discoveries in various verticals of the private sector and introduced the measure of "Economic Readiness Level" as a selection criteria for maturing technologies based on their understanding of their economic potential (ISPCS Speaker Biographies, 2015kk).

Ioana is a featured TedEx "Future Spoiler" speaker and has given numerous (invited) talks in the US and abroad. She holds a PhD in Physics from the University of Groningen, The Netherlands, a Computational Chemistry Research Associate degree from CALTECH and a Biochemistry Research Associate degree from Stanford and has joined NASA Ames Research Center for Nanotechnology in 2003 to design a nano pore sensor for DNA sequencing. Ioana was the first to bring computational chemistry methods in the field of EDL engineering and was responsible for the development of fundamental models for surface catalysis, gas-surface interactions. Through her expertise in reentry systems, Ioana provided support to the Stardust post-flight analysis team and acted in leadership roles for the Orion CEV Margins Management Team, and Material Response team for MSL/MEDLI. She initiated and chaired the first Gordon Research Conference on Atmospheric Reentry Physics, Fundamentals of Environment-Materials Interactions, Models and Design Approaches to Meet Emerging Space Needs (ISPCS Speaker Biographies, 2015kk).

Cottonwood Technology Funds (CTF)

CTF are seed and pre-seed-stage technology commercialization funds with offices in New Mexico, USA and Enschede, The Netherlands. The general partner of the funds has proven itself with top returns in regions rich in innovation but lacking in capital and management – the other critical resources for enabling success. CTF works to provide venture services and capital to tech transfer opportunities with strong commercial potential (CTF, 2015).

The CTF model was first developed and tested in the Southeastern US. Today, the Southwestern US and Northern Europe are experiencing a similar combination of advantages and challenges. Once again, returns are validating their approach, which identifies and supports the development of category-leadership companies. They borrowed their name from a tree that is native to the Southwestern US: the Rio Grande Cottonwood. A welcome sight to pioneer desert caravans because it often signaled water, the Cottonwood typically reaches 50 to 60 feet in height and can produce as many as 25 million seeds in a season. CTF aims to be as fruitful with its work (CTF, 2015).

The CTF Southwest US region stretches from Phoenix to Denver to Austin and includes the Rio Grande Technology Corridor running along the Rio Grande from Los Alamos, New Mexico to El Paso, Texas. As host to three federal labs, multiple medical centers, and more than a dozen premier engineering schools and research universities, this is an area rich in resources. Collectively, these institutions represent more than $10 billion in annual research across critical fields such as biosciences, new energy, nanotechnology, information technologies, cleantech and aerospace (CTF, 2015).

CTF's Northern European region includes Belgium, the Netherlands and Germany. This area is rich in innovation centers and home to numerous multinational corporations including Thales, Shell, Philips, Robert Bosch, KLM and Sabic. The region's innovation areas of expertise are similar to those of the Southwestern US, making it compatible with their network and existing portfolio focus areas (CTF, 2015).

Managing Director: Dave Blivin

Mr. Blivin is based in Santa Fe, New Mexico and has over 25 years of private equity, operating and investment experience. Mr. Blivin has successfully made and managed investments in over 30 private technology based companies. He has been an early sponsor of companies representing almost $1.5 billion in realized enterprise value. Mr. Blivin has been a founder in three venture fund platforms; Southeast Interactive based in RTP, North Carolina; CTF based in Santa Fe, New Mexico and Cottonwood Euro Fund based in Enschede, Netherlands. These funds represent over $200M in committed capital. Returns have exceeded 3x cash-on-cash. The Cottonwood funds focus on seed stage investments in hard science based technologies including advanced materials, photonics, energy, robotics and healthcare (ISPCS Speaker Biographies, 2015ll).

Before entering the venture capital business, Dave served as the Chief Financial Officer of Montrose Capital Corporation, a merchant-banking firm that formed and managed over 20 limited partnerships representing in excess of $100 million in equity and $350 million in total capitalization. Mr. Blivin has participated on numerous boards of directors including Skorpios Corporation, xF Technologies, Exagen Diagnostics, Respira Therapuetics, A2M, Inc., The Pantry (nasdaq-PTRY), Opensite (sold to Siebel), Accipiter (sold to CMGI), Nitronex, Channelogics (sold to Scientific Atlanta) and Buildnet. He holds an MBA from the Fuqua School of Business at Duke University (ISPCS Speaker Biographies, 2015ll).

Turning Microgravity into a Billion Dollar Business

As the old saying goes, "How do you become a Millionaire in the Space Business? First you start with a Billion dollars!" Since most of us do not have a "B" level bank account, or even an "M" level for that matter, what does it take to get a real microgravity business going these days? Thankfully, the word "microgravity" does not send investors running from the room anymore but there are still some significant obstacles to overcome. This panel provided perspective from an entrepreneur (ACME) working to establish credibility, an academic (Stanford) conducting independent research and evaluation on microgravity commercialization processes, a government contractor at NASA Ames trying to figure out how this fits, or should fit the NASA model, and an investor (CTF) looking for the game changer that will make everybody rich and usher in an entirely new industry.

Topic 26: Marshall's Innovative Partnerships and NASA's Journey to Mars

Joan (Jody) A. Singer, Manager, Flight Programs and Partnerships Office, NASA Marshall Space Flight Center, gave this spotlight talk.

NASA Marshall Space Flight Center

The Marshall Space Flight Center's capabilities and experience are essential to nearly every facet of NASA's mission of exploration and discovery. The following are just some of the NASA missions supported by the Marshall Center: (1) Chandra X-ray Observatory; (2) Discovery Program; (3) Hinode; (4) ISS; (5) New Frontiers Program; (6) Technology Demonstrators Missions; (7) SERVIR; (8) Solar System Exploration; (9) Space Launch System; and (10) SpoRT (Marshall Space Flight Center, 2015a).

NASA's Marshall Space Flight Center (MSFC) is situated on the US Army's Redstone Arsenal in Huntsville, Alabama. While visits to Marshall by the general public are not currently available, visitors are welcomed at the US Space and Rocket Center, which serves as Marshall's Visitor Information Center. There, visitors can learn more about Marshall's legacy and ongoing work. Interactive exhibits and unique historic artifacts provided by the Marshall Center demonstrate their critical role in supporting the breadth of NASA's missions (Marshall Space Flight Center, 2015b).

Manager, Flight Programs and Partnerships Office: Joan (Jody) A. Singer

Joan (Jody) A. Singer is the Program Manager for the Flight Programs and Partnerships Office (FPPO) at NASA's Marshall Space Flight Center in Huntsville, Alabama. She has been serving in this position since June 2013. As the FPPO manager, she is responsible for the overall management and direction of the office, including an annual budget of $108 million and a combined workforce of more than 500 civil-service employees and contractors. She holds primary responsibility for managing the implementation of the center's work portfolio in the areas of human exploration transportation and development projects; planetary science and technology programs; and the ISS life control systems and payload integration and operations. The office also serves as the 'front door' for partnership opportunities (Space Act Agreements (SAA)) with other government agencies, international, academia, industrial, and commercial partners (ISPCS Speaker Biographies, 2015mm).

Ms. Singer was appointed to one of the most prestigious and top managerial positions in the federal agency as a Senior Executive Service (SES) member in 2002. During her career, Ms. Singer has held significant roles of responsibility in NASA, including the deputy program manager of the Space Launch System (SLS), the nation's next heavy-lift launch vehicle, which will enable a new era of deep space human exploration and science. In SLS, she oversaw a combined workforce of almost 3,000 civil servants and contractors with an annual budget of more than $1.6 billion. Prior to SLS, Ms. Singer held numerous leadership roles in the Space Shuttle Propulsion Office including, deputy manager of the Space Shuttle Propulsion Office, the Reusable Solid Rocket Booster Project Manager, External Tank deputy manager and as an engineering lead in the Space Shuttle Main Engine Office. Major accomplishments during her tenure in Shuttle, from 1987 to 2011, include being a mission manager team member during numerous shuttle missions, leading the solid rocket team during the Columbia Incident Return to Flight activities, and serving as the Propulsion Office deputy during the safe fly out and conclusion of the Space Shuttle Program in 2011. In addition to her Shuttle deputy roles, in 2010, she served in a dual capacity as deputy project manager for the Ares Project Office during its final year of operation, helping to oversee the smooth and affordable transition of the shuttle and constellation workforce, technologies, and assets to the SLS program (ISPCS Speaker Biographies, 2015mm).

Prior to NASA, Ms. Singer began her engineering career in industry as a methods engineer at Packard Electric, a division of General Motors, in Jackson, Mississippi. She was responsible for planning layout and assembly of automobile electrical wiring harnesses. Singer earned a bachelor's degree in industrial engineering from the University of Alabama in Tuscaloosa in 1983. She has completed many executive- and management-level training courses, including two NASA Fellowships, at Pennsylvania State University in State College and at the Simmons College Graduate School of Management in Boston (ISPCS Speaker Biographies, 2015mm).

Marshall's Innovative Partnerships and NASA's Journey to Mars

The success of NASA's Partnerships is leading to exciting, innovative technologies and helping expand the scope of human exploration. From commercial crew advancement to additive manufacturing to cutting-edge propulsion development, these dynamic partnerships spur innovations that solve technical problems and transfer technology to the commercial sector. With over 300 active partnership agreements, NASA's Marshall Space Flight Center Partnerships Office connects innovators to NASA's technology portfolio, facilities, and world-class expertise, as well as ISS opportunities and connections across NASA's field centers. Jody Singer, Marshall Space Flight Center's Flight Programs and Partnership Office Program Manager, discussed Marshall's roles with partners, including Dynetics, Teledyne Brown Engineering, Sierra Nevada, Lockheed Martin, Ball Aerospace, Orbital ATK, US Air Force, DARPA, and the University of Alabama.

Singer began her presentation by stating that partnership is a key to mission success. NASA's agency budget is split between the following: (1) Science Technology Mission Directorate (STMD); (2) Cross Agency Support; (3) Aeronautics; (4) Education; (5) Science Mission Directorate (SMD); (6) Human Exploration and Operations Missions Directorate (HEOMD). HEOMD scope of work includes MSFC Access partnerships: Michoud Assembly Facility, Space Technology, Science, MSFC Engineering Capabilities, Advanced Exploration Systems, ISS, Commercial Cargo, Commercial Crew, and other NASA centers. MSFC's most utilized capabilities and expertise includes propulsion, structures, testing (environmental, structural, and propulsion), materials and processes and advanced manufacturing (3-D printing and composites) (Singer, 2015).

Topic 27: The Era of In-Space Manufacturing has begun

Andrew Rush, President of Made In Space, gave this spotlight talk.

Made In Space

Founded in 2010 with the goal of enabling humanity's future in space, Made In Space, Inc. has developed additive manufacturing technology for use in zero gravity. By constructing hardware that can build what is needed in space, as opposed to launching it from Earth, the company plans to accelerate and broaden space development while also providing unprecedented access for people on Earth to use in-space capabilities (Made In Space, 2015).

Made In Space's team consists of successful entrepreneurs, experienced space experts and key 3-D printing developers. With over 30,000 hours of 3-D printing technology testing, and more than 400 parabolas of microgravity test flights, Made In Space’s experience and expertise has led to the first 3-D printers designed and built for use on the ISS (Made In Space, 2015).

President: Andrew Rush

Andrew Rush is president of Silicon Valley-based Made In Space, Inc. He oversees the operations, business development, and strategy of Made In Space as it continues to push boundaries at the forefront of in-space manufacturing, 3-D printing in space, at sea, and in other extreme environments, and space colonization-related technologies (ISPCS Speaker Biographies, 2015nn).

Previously, Andrew was an intellectual property attorney. He was one of the few intellectual property lawyers nationally with established industry specializations 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. Andrew has also worked with Masten Space Systems. Before becoming an attorney, he was a research assistant in a solid-state physics laboratory. Andrew holds a Bachelor of Science degree in physics and a Juris Doctorate degree from Stetson University (ISPCS Speaker Biographies, 2015nn).

The Era of In-Space Manufacturing has begun

On November 24, 2014, a team of engineers at NASA and Made In Space, Inc. created the first object ever manufactured in space. With it, individuals, schools, companies and even governments no longer have to hurl pre-built goods into space. On-orbit manufacturing and assembly of everything from individual components to entire spacecraft changes the economics of spaceflight, how missions are designed and the speed at which in space activities may be carried out. Made In Space president Andrew Rush discussed how in-space manufacturing capabilities that exist today enable tech development, tech demonstration, part delivery, equipment fixes, operational life extension and even spacecraft creation by anyone.

Conclusion

This paper was meant to provide an industry snapshot of the current state of events in the commercial space industry in 2015. It was written through the eyes of the ISPCS because that is one of the nation’s foremost symposia on this topic. If the content of this paper has made you a well-informed reader on this topic then the author has only partially met her goal. However, if this paper has inspired and excited you about this rapidly transforming industry then the author has accomplished her goal in its entirely. To the Karman line and beyond, my fellow Earthlings!

References

Acme Advanced Materials, Inc. (2015). ACME Advanced Materials Produces Commercial SiC Wafers in Microgravity. Retrieved from http://www.parabolicarc.com/2014/09/10/acme-advanced-materials-produces-commercial-sic-wafers-micogravity/

AirStrato. (2015a). A revolution for everyone. Retrieved from http://www.airstrato.com

AirStrato. (2015b). Explorer. Retrieved from http://www.airstrato.com/en/explorer.html

AirStrato. (2015c). Pioneer. Retrieved from http://www.airstrato.com/en/pioneer.html

AirStrato. (2015d). Accelerator. Retrieved from http://www.airstrato.com/en/accelerator.html

AirStrato. (2015e). Interface. Retrieved from http://www.airstrato.com/en/interface.html

American Institute of Aeronautics and Astronautics (AIAA). (2015a). Exhibitor Information. Retrieved from http://www.ispcs.com/exhibitors_15.php

American Institute of Aeronautics and Astronautics (AIAA). (2015b). About AIAA: Did you know? Retrieved from https://www.aiaa.org/AboutAIAA/

ARCA Space Corporation. (2015). About Us. Retrieved from http://www.arcaspace.com/en/about_us.htm

Bessemer Venture Partners (BVP). (2015). History of BVP. Retrieved from https://www.bvp.com/about/history

Best, J. (2015, October). Leveraging Supplier Pedigree and Technology for Commercial Space. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Blue Origin. (2015). Start your journey. Retrieved from https://www.blueorigin.com

Brost, J. (2015, October). Commercial Cargo Transportation to the ISS – Learning as a Team. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Center for the Advancement of Science in Space (CASIS). (2015). About CASIS. Retrieved from http://www.iss-casis.org/About/AboutCASIS.aspx

Commercial Spaceflight Federation (CSF). (2015). About Us. Retrieved from http://www.commercialspaceflight.org/about-us/

Cottonwood Technology Funds (CTF). (2015). About. Retrieved from http://cottonwoodtechnologyfund.com/about/

Culbertson, Jr. F. L. (2015, October). Commercial Cargo Resupply Service: Supporting the International Space Station. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Defense Advanced Research Projects Agency (DARPA). (2015). About us. Retrieved from http://www.darpa.mil/about-us/about-darpa

DeMauro, F. (2015, October). Commercial Cargo Transportation to the ISS – Learning as a Team. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Federal Aviation Administration (FAA). (2011). Public Meeting on the Regulatory Approach for Commercial Orbital Human Spaceflight. Retrieved from http://www.faa.gov/about/office_org/headquarters_offices/ast/meeting_regulatory_approach/

Ferguson, C. J. (2015, October). What's next for Low Earth Orbit (LEO)? What's after ISS and who will build it and pay for it? In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Hill, G. C. (2015, October). Spaceport America's Other Business. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

International Symposium for Personal and Commercial Spaceflight (ISPCS). (n.d.a). Making a Difference. Retrieved from http://www.ispcs.com

International Symposium for Personal and Commercial Spaceflight (ISPCS). (n.d.b). Bienvenidos. Retrieved from http://www.ispcs.com/about_ispcs.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015a). Speaker Biographies. Retrieved from http://www.ispcs.com/pat_hynes_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015b). Speaker Biographies. Retrieved from http://www.ispcs.com/ariane_cornell_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015c).

Speaker Biographies. Retrieved from http://www.ispcs.com/wayne_hale_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015d). Speaker Biographies. Retrieved from http://www.ispcs.com/cynda_collins_arsenault_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015e). Speaker Biographies. Retrieved from http://www.ispcs.com/frank_culbertson_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015f). Speaker Biographies. Retrieved from http://www.ispcs.com/sandra_h_magnus_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015g). Speaker Biographies. Retrieved from http://www.ispcs.com/robert_meyerson_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015h). Speaker Biographies. Retrieved from http://www.ispcs.com/christopher_ferguson_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015i). Speaker Biographies. Retrieved from http://www.ispcs.com/john_h_jay_gibson_ii_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015j). Speaker Biographies. Retrieved from http://www.ispcs.com/mike_simpson_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015k). Speaker Biographies. Retrieved from http://www.ispcs.com/jill_reckie_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015l). Speaker Biographies. Retrieved from http://www.ispcs.com/brad_mclain.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015m). Speaker Biographies. Retrieved from http://www.ispcs.com/douglas_young_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015n). Speaker Biographies. Retrieved from http://www.ispcs.com/melissa_sampson_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015o).

Speaker Biographies. Retrieved from http://www.ispcs.com/will_pomerantz_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015p). Speaker Biographies. Retrieved from http://www.ispcs.com/alexander_macdonald_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015q). Speaker Biographies. Retrieved from http://www.ispcs.com/pam_melroy_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015r). Speaker Biographies. Retrieved from http://www.ispcs.com/gregory_johnson_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015s). Speaker Biographies. Retrieved from http://www.ispcs.com/peter_wegner.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015t). Speaker Biographies. Retrieved from http://www.ispcs.com/eric_stallmer.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015u). Speaker Biographies. Retrieved from http://www.ispcs.com/johannes_torpe_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015v). Speaker Biographies. Retrieved from http://www.ispcs.com/frank_demauro_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015w). Speaker Biographies. Retrieved from http://www.ispcs.com/josh_brost_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015x). Speaker Biographies. Retrieved from http://www.ispcs.com/mark_sirangelo_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015y). Speaker Biographies. Retrieved from http://www.ispcs.com/mark_peller_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015z). Speaker Biographies. Retrieved from http://www.ispcs.com/kathy_lueders_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015aa). Speaker Biographies. Retrieved from http://www.ispcs.com/john_mulholland_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015bb). Speaker Biographies. Retrieved from http://www.ispcs.com/garrett_resiman_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015cc). Speaker Biographies. Retrieved from http://www.ispcs.com/jason_best_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015dd). Speaker Biographies. Retrieved from http://www.ispcs.com/george_whitesides_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015ee). Speaker Biographies. Retrieved from http://www.ispcs.com/stuart_witt_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015ff). Speaker Biographies. Retrieved from http://www.ispcs.com/thomas_r_ingersoll_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015gg). Speaker Biographies. Retrieved from http://www.ispcs.com/sunil_nagaraj_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015hh). Speaker Biographies. Retrieved from http://www.ispcs.com/garrett_hill_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015ii). Speaker Biographies. Retrieved from http://www.ispcs.com/dumitru_popescu_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015jj). Speaker Biographies. Retrieved from http://www.ispcs.com/rich_glover_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015kk). Speaker Biographies. Retrieved from http://www.ispcs.com/ioana_cozmuta_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015ll). Speaker Biographies. Retrieved from http://www.ispcs.com/dave_blivin_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015mm). Speaker Biographies. Retrieved from http://www.ispcs.com/jody_singer_bio.php

International Symposium for Personal and Commercial Spaceflight (ISPCS). (2015nn). Speaker Biographies. Retrieved from http://www.ispcs.com/andrew_rush_bio.php

Johannes Torpe Studios. (2015). About. Retrieved from http://johannestorpestudios.com/about/studio/

Library of Congress. (2015). H.R. 2262. Retrieved from https://www.congress.gov/bill/114th-congress/house-bill/2262

Lueders, K. (2015, October). The Power of Partnerships with Private Industry. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

MacDonald, A. (2015, October). The Evolving Landscape of 21st Century Spaceflight. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Made In Space. (2015). Company Press Kit. Retrieved from http://madeinspace.us/presskit/

Magnus, S. H. (2015, October). The Multiple Roles of Professional Societies. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Marshall Space Flight Center. (2015a). Overview. Retrieved from http://www.nasa.gov/centers/marshall/overview.html

Marshall Space Flight Center. (2015b). Visiting Marshall. Retrieved from http://www.nasa.gov/centers/marshall/about/visitor.html

McLain B. (2015, October). The Work of Creating Effective Work Teams. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Melroy, P. (2015, October). Disruptive Technologies for New Space Future. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Meyerson, R. (2015, October). Making a Difference – Step-by-Step, Ferociously. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Mojave Air and Space Port. (2015). About. Retrieved from http://www.mojaveairport.com/about.html

Mulholland, J. (2015, October). NASA's Commercial Crew Program: Experience-Guided Innovation. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

National Aeronautics and Space Administration (NASA). (2015a). About NASA. Retrieved from https://www.nasa.gov/about/index.html

National Aeronautics and Space Administration (NASA). (2015b). What does NASA do? Retrieved from https://www.nasa.gov/about/highlights/what_does_nasa_do.html

NASA Ames Research Center. (2015). About our Center. Retrieved from https://www.nasa.gov/centers/ames/about/index.html

National Center for Women & Information Technology (NCWIT). (2015). Retrieved from https://www.ncwit.org/ncwit-fact-sheet

Northrop Grumman. (2015a). About us. Retrieved from http://www.northropgrumman.com/AboutUs/Pages/default.aspx

Northrop Grumman. (2015b). FAQ. Retrieved from http://www.northropgrumman.com/AboutUs/Pages/FAQ.aspx

Orbital ATK. (2015). Exhibitor information. Retrieved from http://www.ispcs.com/exhibitors_15.php

Reckie, J. (2015, October). The Work of Creating Effective Work Teams. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Reisman, G. (2015, October). NASA's Commercial Crew Program: Experience-Guided Innovation. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Secure World Foundation (SWF). (2011). Who We Are. Retrieved from http://swfound.org/about-us/who-we-are/

Secure World Foundation (SWF). (2015a). Space sustainability. Retrieved from http://swfound.org/media/121399/swf_space_sustainability-a_practical_guide_2014__1_.pdf

Secure World Foundation (SWF). (2015b). 2014 Annual Report. Retrieved from http://swfound.org/media/195241/2014_swf_annual_report_to_the_board.pdf

Sierra Nevada Corporation (SNC). (2015). About Sierra Nevada Corporation. Retrieved from http://www.sncorp.com/AboutUs/AboutSNC

Singer, J. A. (2015, October). Marshall's Innovative Partnerships and NASA's Journey to Mars. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Sirangelo, M. (2015, October). Commercial Cargo Transportation to the ISS – Learning as a Team. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Skybox Imaging. (2015). Company. Retrieved from http://www.skyboximaging.com/company#about

Space Politics. (2013). Congress planning an update to commercial launch legislation this year. Retrieved from http://www.spacepolitics.com/2013/02/10/congress-planning-an-update-to-commercial-launch-legislation-this-year/

Spaceflight Industries (Spaceflight). (2015). Our Story. Retrieved from http://www.spaceflightindustries.com/company/

SpaceX. (2015). Company. Retrieved from http://www.spacex.com/about

Stallmer, E. (2015, October). Making a Difference – One Future Space Leader at a Time. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Stellar Technology. (2015). Exhibitor Information. Retrieved from http://www.ispcs.com/exhibitors_15.php

The Boeing Company. (2015a). General Information. Retrieved from http://www.boeing.com/company/#/general-information

The Boeing Company. (2015b). Overview. Retrieved from http://www.boeing.com/company/about-bds/

United Launch Alliance (ULA). (2015a). Company History. Retrieved from http://www.ulalaunch.com/history.aspx

United Launch Alliance (ULA). (2015b). Quick Facts. Retrieved from http://www.ulalaunch.com/about_quickfacts.aspx

Virgin Galactic. (2015a). Who We Are. Retrieved from http://www.virgingalactic.com/who-we-are/

Virgin Galactic. (2015b). LauncherOne Operations. Retrieved from http://www.virgingalactic.com/satellite-launch/l1-operations/

Virgin Galactic. (2015c). Big Value For Small Satellites: Announcing Improvements To LauncherOne. Retrieved from http://www.virgingalactic.com/big-value-for-small-satellites-announcing-improvements-to-launcherone/

Virgin Galactic. (2015d). LauncherOne In-House Rocket Propulsion Team Achieves Key Test Milestones. Retrieved from http://www.virgingalactic.com/launcherone-in-house-rocket-propulsion-team-achieves-key-test-milestones/

Wegner, P. (2015, October). Does Persistence Pay? In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

Whitesides, G. T. (2015, October). Virgin Galactic: Entrepreneurship and the New Space Economy. In International Symposium for Personal and Commercial Spaceflight. Symposium conducted at the New Mexico Farm and Ranch Heritage Museum, Las Cruces, NM.

XCOR Aerospace. (2015). Company Overview. Retrieved from http://www.xcor.com/about-us/company-overview/

X2nSat. (2015). About X2nSat. Retrieved from http://www.x2nsat.com/about-x2nsat