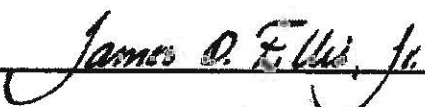





NATIONAL SPACE COUNCIL
USERS' ADVISORY GROUP

April 8, 2019
Broadmoor Hotel International Center
Colorado Springs, CO

MEETING MINUTES

Adm. James Ellis (USN, Ret.), Chair

Mr. Brandon Eden, Executive Secretary

**National Space Council Users' Advisory Group
Broadmoor Hotel International Center
Colorado Springs, CO**

**Minutes of the Third Meeting
April 8, 2019**

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*Meeting Report prepared by
Mary Beth Saffo
Zantech*

Opening Remarks

At 1:00 pm MDT, Mr. Brandon Eden, executive secretary and designated federal officer for the National Space Council Users' Advisory Group (UAG), welcomed attendees to the 3rd meeting of the UAG. Mr. Eden noted that the UAG was formally chartered by NASA December 6, 2017, and that NASA sponsors the UAG at the request of and on behalf of the White House. The purpose of the UAG is to ensure that the interests of industry, other non-federal entities, and other persons involved in aeronautical and space activities are represented in the National Space Council. Meetings are open to the public; its proceedings are part of the public record. and all comments by UAG members are on the record.

The UAG consists of two categories of members, each appointed by the NASA administrator, James Bridenstine: (1) representatives of particular industry sectors or entities and (2) special government employees (SGEs) to serve as subject matter experts. All SGEs undergo mandatory ethics training and should recuse themselves if they have a conflict of interest with the topic at hand.

Mr. Eden then introduced UAG Chair Admiral James Ellis, who called the meeting formally to order. Adm. Ellis expressed his appreciation to the Space Foundation for providing time and space at the 35th Space Symposium for the UAG meeting and introduced the afternoon's agenda.

Before turning to other speakers, Adm. Ellis expanded briefly on Mr. Eden's overview of UAG activities. The UAG, he said, provides subject matter expertise to the NSpC, submits reports with findings and recommendations to the Council, and submits an annual report to the Council on UAG activities. Admiral Ellis stressed that the UAG belongs to all users of space. In the deliberations and proceedings of the NSpC, the UAG thus has both the opportunity and the obligation to represent the interests of all users, not only those of the UAG members themselves.

Committee Business

The UAG includes 6 subcommittees, each devoted to a distinct topic related to the space mission:

- Exploration and discovery
- National security
- Economic development and industrial base
- Technology and innovation
- Outreach and education
- Space Policy and International Engagement

Two of the subcommittees – Exploration and Discovery and National Security – were able to provide updates at this meeting.

Gen. Lester Lyles, chair, summarized the work of the *Exploration and Discovery* subcommittee. The chief focus of the subcommittee's most recent discussions has been to examine the current architecture of the lunar initiative, the mechanisms for flexibility embodied in the current plan, and possible alternatives to that plan. The subcommittee is also considering a recommendation for external assessment of the lunar exploration architecture by the National Academies or other independent group. The subcommittee has defined a list of key questions essential for assessment of the current lunar exploration plans:

- What is the goal of the lunar exploration program? What assumptions have been made in defining that goal? (This question was recently answered by the Vice President, who announced at the end of March an accelerated goal of returning astronauts to the Moon by 2024).
- What tradeoffs have been examined in the process of developing the plan?
- What alternative funding possibilities, with respect to government, international, or commercial resources, have been explored, to best achieve the goals of the program?

- The subcommittee also expressed the need for greater knowledge of legislative and budget concerns in order to provide a realistic analysis of the program.

Gen. Lyles offered his personal recommendation that the UAG form a task force to act as a “red team” to assess the revised lunar exploration plan, as well as possible alternatives to that plan. He proposed to populate the task force with UAG members or with designated subject-matter experts from the sectors represented by UAG members. Gen. Lyles also suggested reaching out to entities such as the National Academy of Engineering, which has expertise in space architecture, or to the NASA Advisory Council (NAC), also chaired by Gen. Lyles, as additional sources of external expertise.

The proposed red team would work to align its assessment plans with NASA activities, and to provide added value to, rather than to distract from, its mission. Gen. Lyles noted that NASA has already started to address some of these questions, and that the task force would plan to keep in communication with NASA as their plans progressed, with the goal of providing useful advice before plans are finalized.

Mr. Salvatore (Tory) Bruno expressed his full support for Gen. Lyles' task force recommendation and stated that he would fully commit resources to realizing this proposal. Adm. Ellis commented that the most effective red teams are small and focused, and made up of members with deep expertise with the issues at hand. As NASA wrestles with the aggressive schedule for lunar exploration, the proposed red team would have to be prepared to move at a fast pace, with regular meetings, to match the pace of NASA's own accelerated deadlines. He also emphasized the need for developing clear goals for the task force, and he cautioned the group about the potential for conflicts of interest between the goals of the task force and the individual priorities of the red team members or external experts. Gen. Lyles reassured the UAG members that he was very mindful of the need to keep the missions and activities of the UAG and NAC distinct.

Fatih Ozmen, who also offered his support to the proposed task force, suggested that the group consider adopting the Analysis of Alternatives (AoA) approach used by DOD as a methodology for objective assessment of possible alternatives to the current plan for realizing the 2024 goal of returning humans to the Moon. Gen. Lyles affirmed that NASA's approach thus far incorporates at least the general principles of AoA methodology.

As an action item, Adm. Ellis proposed refinement of Gen. Lyles' task force proposal, followed by submission of that proposal to the UAG for discussion and final approval. Noting that the initial concepts are promising, he reiterated the need to precisely define both the goals of the task force and the processes to be used to achieve those goals.

As chair of the *National Security subcommittee* of the UAG, Adm. Ellis updated the meeting attendees on the subcommittee's recent activities. The subcommittee met on April 5 to discuss the request by the National Space Council that the subcommittee examine the organizational construct of the newly defined Space Force. More specifically, the subcommittee has been asked to assess and to recommend options for the organizational structure of the uniformed Space Force, including a future Department of the Space Force. The subcommittee has been promised access to the Department of Defense (DOD) and other relevant organizations to facilitate completion of this task. The goals of the Space Force are ambitious and wide-ranging, and there is much work to be done to create from its general goals an efficient and effective functioning entity, including resolving the special challenges of massive organizational change. In order to provide appropriate and useful advice, it will be important for subcommittee members to have access to, and continuing conversations with, those staff members at DOD and elsewhere who are doing the hard job of bring these ambitious goals to fruition.

Gen. Lyles stressed the importance of subcommittee access to DOD, especially for those members without military experience who may not already have special access privileges with DOD. Adm. Ellis agreed, noting that the promise of DOD access has yet to be tested. He also added that many of the non-military members of the National Security subcommittee have themselves created or led large companies; these members thus bring to the subcommittee deep experience with effecting or managing organizational change that will be very important to carrying out this task.

The Emergence of the Space Force

Mr. Doug Loverro (Loverro LLC; Former Deputy Assistant Secretary of Defense for Space Policy) and Marc Berkowitz (Vice President for Space Security, Lockheed Martin)

After recounting the rich careers of Mr. Berkowitz and Mr. Loverro, Adm. Ellis asked the speakers to offer their views of the emerging Space Force, especially with regard to the questions: what have the organizers got right, what aspects need improvement, and what features of the Space Force still need to be defined.

Mr. Berkowitz outlined the DOD plan to establish the Space Force as the 6th branch of the armed services. Citing his long service, he noted his participation in almost every review of management organization, including the transition study that discussed implementation of the Space Commission's recommendations for security in space. Mr. Berkowitz emphasized that he would be speaking only as a private citizen, and stressed that his views did not necessarily reflect those of Lockheed Martin, DOD, or any other organization with which he has been affiliated.

National security management and organization in space has been a recurring issue. Common concerns about national security management have included fragmented management and widely distributed and misaligned channels of authority, responsibility and accountability. Symptoms of these problems include inadequate stewardship; inadequate personnel management; cumbersome decision-making; budget instability; lack of a war-fighting ethos; insufficient integration of defense and intelligence activities; and inadequate unity of command. This situation has had profound consequences for U.S. readiness in space. In the last 3 or 4 decades, there have been numerous studies of the problem; but none of these studies have yet yielded the necessary change.

In 2001, the Space Commission summarized the need for changing the status quo, with a statement that continues to be relevant today:

History is replete with instances in which warning signs were ignored and change resisted until an external, "improbable" event forced resistant bureaucracies to take action. The question is whether the U.S. will be wise enough to act responsibly and soon enough to reduce U.S. space vulnerability. Or whether, as in the past, a disabling attack against the country and its people—a "Space Pearl Harbor"—will be the only event able to galvanize the nation and cause the U.S. Government to act.

Report of the Commission to Assess United States Space Security Management and Organization, 2001

Nearly two decades later, the international security environment is characterized by renewed great-power competition and challenges to the rules-based established international order. China and Russia seek to reshape the international system along authoritarian models, to dominate their regional spheres of influence, and to expand their global reach. They have studied our military training and methods closely. They understand America's strategic advantage in space, and the leverage we gain by integrating space assets with capabilities in all domains to achieve U.S. national security objectives, and they know that we

rely on space systems to achieve decision superiority and to project our power with precision, speed, and lethality.

Consequently, China and Russia are aggressively seeking to undermine our leadership position in space. Both countries regard space as a war-fighting domain in which they can coerce the United States and they are developing weapon systems that could threaten our access to space, jeopardize U.S. and Allied military forces, and endanger our national security. Unlike the space threats we faced in the Cold War, we currently face sophisticated, fast-paced, multidomain threats from multiple great powers. Attacks on space assets can be made both rapidly and ambiguously, simultaneously making rapid response essential while also increasing the challenge of the equally essential task of correctly identifying the attacker. Because of our reliance on space assets in many domains of life, the stakes of space warfare are especially high, with the potential for attacks on political and economic assets, as well as conventional military and intelligence targets.

Today, the U.S. is world's greatest space-faring nation. The U.S. government has long recognized that unimpeded access to space is vital to our national interests, including everyday functioning of our society as well as military and intelligence capabilities. Disruption or loss of critical space assets could be decisive to the outcome of international conflicts. The renewal of Great Power competition, including renewed threats to space assets, has prompted needed policy debates about the readiness of the military establishment to address these threats, and provides a once-a-generation opportunity to implement a government structure that will protect and advance our interests in space.

The central question is whether the Department of Defense plan is either an improvement over the status quo or superior to alternative approaches. Sustaining and expanding upon the actions of previous administrations, the Trump administration has moved to address space security challenges on several fronts. It has been formulating strategy, prioritizing investments in modern defense and intelligence capabilities, continuing to emphasize the development of the National Defense Center, revitalizing the National Space Council, reestablishing the U.S. Space Command creating the Space Development Agency, and, if Congress legislation is approved, establishing the Space Force.

The DOD plan addresses several concerns about the status quo:

1. *Fragmentation*: Creating the space force as an independent service within the Dept. of the Air Force is a fiscally responsible approach, and the unified direction of specialized space force training and combatant and command operations provided by this place reflects a prudent awareness of the need for military readiness for conflicts in space. Despite these improvements, it should be noted that the current plan does not consolidate all space defense operations, many of which will still be scattered among several DOD offices and agencies. In addition, the creation of the Space Development Agency seems likely to be an additive initiative to existing DOD space-oriented offices, rather than one that can unify operations, clarify responsibilities, or streamline decision-making.

2. *Insufficient Advocacy*: The Secretary of the Air Force, the Undersecretary of Space, the Space Force Chief of Staff, the Commander of Space Command, and other senior-level military and civilian staff will have the stature and experience to argue forcefully and effectively for Space Force requirements and resources. They will also be well-positioned to advocate for Space Force requirements at the highest levels of government.

3. *Alignment of authority, responsibility, and accountability*. The establishment of the Space Force and reestablishment of the Space Command will require reorganizational efforts, and alignment of authority, responsibility, and accountability. No organizational structure can be perfectly optimized for every purpose, but the right culture and people can often overcome suboptimal organizational design. Treating

the Space Force as a separate, unified service will allow the development of the distinct institutional values and practices necessary for the training, recruiting, and professional development of a group of world-class space scientists, engineers, and warriors prepared to handle the special strategic and tactical challenges of defending national security in space.

In his concluding remarks, Mr. Berkowitz noted that the details of implementation are critical and that many aspects of the DOD plan are still opaque or undetermined. For this reason, effective evaluation of the plan is essential, to assess whether the plan is succeeding in its goal of reversing the erosion of our country's strategic advantages in space and addressing military readiness in space. Metrics of success might include streamlined decision-making processes; breadth and depth of personnel in the space field; educational and certification procedures; promotion rates; discipline and efficiency of procurement programs; maturity and effectiveness of joint command and control arrangements, warning systems and intelligence support, war plans, and combined operational practices.

Mr. Douglas Loverro opened his presentation with a quote from Paul W. Beck, one of the first advocates for an air service separate from the U.S. Army. Beck offered an opinion in 1911 that remains relevant today: "Necessity for a permanent organization is recognized, but no one wants to work out the problem. All our legislation has been piecemeal. We are all by habit and training fearful of the results of new legislation, particularly as it relates to the creation of new organizations." The nation, said Mr. Loverro, needs a Space Force, and needs one now. If we are truly serious about keeping the U.S. in the lead in space; if we are truly serious about protecting space for the good of our nation and its peaceful use for all the world; if we are truly serious in assuring that U.S. war fighters never lose the advantage in space, then we must move forward, for several reasons. First, it is important to understand the problems that we are trying to solve. The first of these problems is the fact that the threat to U.S. space activities is growing and spreading, and the U.S. must be prepared to defend its use of the space domain in the future. To address this threat, the U.S. needs an organization focused on training, planning, and exercising in the space domain. The U.S. Space Command, which enjoys broad popular support, is a necessary element in resolving this threat. A combatant command creates war planning and strategy; it creates necessary alliances and partnerships to defend its domain. All of these capabilities are missing from current policy, which, thus far, has treated military defenses in space as secondary to nuclear warfare. Because space capability is so central to all aspects of military readiness, development of military defenses in space must be first priority.

A second criticism is that space acquisition is too slow and too invested in legacy priorities. DOD has tried to address this problem by continuing to add more organizations and units devoted to space. Although some analysts view these multiple agencies as providing unnecessary and possibly conflicting duplications of effort, Mr. Loverro viewed these multiple agencies as different sides of the same experiment. In the long term, the U.S. will need to reconcile the duplication, to resolve possibly conflicting priorities of the separate agencies, and to create a simpler organizational framework where individual units ideally work in synergy. But in the short term, each of these agencies has the potential to offer valuable lessons, and there is merit to letting that learning process take its course.

In the meantime, development of the Space Force is essential. The central question – how to train, organize, and equip space forces (that is, development of the *personnel*) is an urgent priority, and it is also the driving rationale for creation of a Space Force. Answering this question will provide the people, the culture, the organizational identity, the advocacy, and the technical and operational arts necessary to support the other dimensions (addressing the threat, and processes of space acquisition) of the problem. It is also the crucial element for maintaining U.S. leadership in space. Among other benefits, the Space Force provides the people and doctrine necessary for developing strategy and war plans. It provides a pipeline of technical and operational thinkers to conceive of the necessary systems to acquire. It provides the capacity for rapid response to threats and changes in strategy as new situations arise. Since the

beginning of the 21st century, it has become clear that space capability is essential for military success on Earth, that the military cannot fully carry out its functions without access to and use of space, and that only an organization fully devoted to those ends – the Space Force – is capable of carrying out these essential functions.

Dr. Harrison Schmitt asked each of the speakers to identify one unique characteristic required of the Space Force that is not currently provided in other services. Mr. Loverro replied that a career path for space professionals is currently lacking and urgently needed; development of that career path (already mandated by 2003 law) is the job of the Space Force. Mr. Berkowitz agreed, adding the perspective that the history of development of submarine forces, especially nuclear professionals, might provide a model for how to develop a new class of technically proficient professionals. Mr. Loverro noted that the Space Force is even more technical than the Air Force, and that technical degrees should be a requirement for all space acquisition professionals.

Mr. Stuart Witt suggested that, given the clear need for education and training of space personnel, it might be useful to add the Secretary of Education to the National Space Council.

Reminding UAG members of the recommendations of the Allen Commission on the role of the National Reconnaissance Office (NRO) in space reconnaissance, Gen. Lyles noted that there has been, thus far, no specific mention of intelligence, including especially the NRO, in the Space Force. Mr. Loverro agreed that the role of intelligence in the Space Force is an important issue, but recommended that, at this initial stage, he was inclined to give highest priority to addressing the most serious deficiencies, rather than devote energy to the reorganization of operations, such as the NRO, that were working reasonably well. He did note, however, a limitation of the current personnel system of the NRO: that only the approximately 25% of the NRO made up of Air Force employees can be allowed to transfer back and forth between the NRO and the Space Force. The remaining 75% of the NRO are all civilians, who are currently blocked by the nature of their appointment from transferring to the Space Force. He suggested revision of the personnel structure for civilian appointments to allow the potential for civilian NRO-Space Force transfers in the future, which would have the added benefit of merging civilian and military culture in the Space Force. Dr. Peterson agreed that transferability of civilian personnel would be essential for operations, acquisition, and intelligence, but also noted that doing so even within current DOD structures is already a significant challenge. Although the intelligence community is already working to assure unity of effort across agencies, highly functional operational relationships are crucial. A future space conflict would demand a synchronized, unified approach to intelligence.

In response to Dr. Mandy Vaughn's question about the role of commercial architecture in the Space Force, Mr. Berkowitz replied that commercial goods and services can be used as much as possible, except where issues of public safety and national security preclude that use. It is also essential to make use of international alliances and partnerships in operating in the space domain. Mr. Loverro noted that the Army distinguishes between three kinds of services: "combat arms" (not commercially adaptable), "combat support" (more peripheral activities, with lower military requirements), and "combat services" (the most ancillary activities, most easily outsourced to commercial operations). The Space Force needs to start distinguishing its activities in much the same way. Col. Pamela Melroy observed that space is inherently global, and that international partnerships will be an essential element of the Space Force. Noting the significant differences between interoperability from an aviation perspective and from a space perspective, she asked whether there are any special statutory authorities needed by the Space Force in order to be successful in global partnerships. Mr. Berkowitz replied that this authority is already embodied in Title 10, although it will still be important to include explicit provisions on such issues in the Space Force charter. Mr. Loverro agreed, but noted that there are two kinds of international partnerships: training and equipping forces (easily handled by current regulations) and operational partnerships. It is the responsibility of commanders to create alliances within their area of responsibility (AOR). It will be the

job of the Joint Chiefs of Staff to determine who will be responsible for building alliances with our spacefaring allies.

Mr. Eric Stallmer asked the speakers for suggestions on how to better articulate the importance of the Space Force to overcome skepticism on Capitol Hill. Mr. Loverro agreed that there is an especially strong need to explain the rationale for the Space Force itself, and why an organized training program for the Space Force is so necessary a part of its mission. The need for a Space Force preceded the security threats by at least a decade. The threat only makes the creation of the Space Force that much more urgent a priority.

Colonel Eileen Collins asked how development of the Space Force would affect the evolution of space situational awareness and space traffic management, as highlighted in Space Directive 3 (SD-3). Mr. Loverro replied that, just as we need a civilian (FAA) and a military (Air Force) air-traffic control system, we also will need separate systems for control of commercial and military space traffic. Mr. Berkowitz added that the continued growth of commercial space activities will encourage a phased transition to separate commercial and military space traffic control systems, to allow the military to focus on its core job of national defense.

Mr. Tim Ellis asked about possible incentives to build a distinct culture in the Space Force, especially with regard to space acquisition. Mr. Loverro expressed a need for space acquisition officers who can adapt the Federal Acquisition Regulation (FAR) procedures for space acquisition, which is less oriented toward production, and more towards research, than acquisition in other services.

Space Spectrum: Challenge & Opportunity

Jennifer Warren (Vice President for Technology Policy & Regulation, Lockheed Martin) and Jennifer Manner (Senior Vice President for Regulatory Affairs, EchoStar)

Ms. Warren and Ms. Manner made a joint presentation.

Adequate spectrum is essential for maintenance of U.S. global leadership in space, for commercial and scientific activities, and for national security. Space Policy Directive 2 (SPD-2) correctly focused on the importance of international spectrum access to the space domain. The recent Dept. Commerce recommendations for needed incremental improvements in spectrum policy are a welcome response to that directive. Drawing on decades of experience in both government and commercial aspects of spectrum management and regulation, Ms. Warren and Ms. Manner highlighted three areas:

- 1) The role of national and international spectrum policy in defining the future of space opportunity.
- 2) The importance of predictable and stable national and international regulatory frameworks for spectrum, especially given the long lead times required for deploying and operating systems in one of the harshest and unforgiving environments.
- 3) The need for reform, and approaches to leverage spectrum policy to advance, rather than hinder, national priorities.

Spectrum management policy is of fundamental importance to space activities and can affect the future direction in space. There is, however, no such thing as a "space spectrum." While there are allocations for space, there is not an interchangeable pot of spectrum that can be used by every space user. Every category of spectrum use—earth exploration, navigation and positioning, communication, and remote sensing, among other applications—uses a different sliver of spectrum in which they seek to operate. Spectrum is managed at both the national and global level, and the table of spectrum allocation of the International Telecommunications Union (ITU) has treaty status. Under ITU treaty obligations, each country is free to use their allocated spectrum in any way it wishes, but it must not interfere with any

other country's use of that spectrum, provided that the other country's spectrum use is in compliance with the treaty. The inherently global nature of space highlights the importance of global harmonization of spectrum regulation. Scientific, commercial and national security interests have worked together for decades to secure and maintain significant blocks of spectrum in which present and future applications can develop. But these same spectrum building blocks, which have enabled a recent explosion of new satellite applications, are also the targets for disruption and are of regulatory interest.

The technological and economic realities of space also affect spectrum allocations. In terms of technology, there is little recognition by regulatory bodies that development of space architecture requires a much longer lead time than standard technology, because of the special technical challenges of operating in the harsh environment of space. There is also a good deal of regulatory impatience in space; spectrum adjustments that involve a launch are a much complicated and costly proposition than adjustments to terrestrial systems.

A key economic factor is the fact that space is inherently a risky enterprise, which makes financing particularly difficult. The financial risks of space enterprises only highlight the importance of regulatory certainty and clarity. Unlike terrestrial networks, which can realize financial return incrementally, space-based networks have a long lead time before they can earn a dollar. A third issue is licensing. Most satellite systems cover multiple countries and need to use that capability. This capability requires not only a licensing administration, but also market access to the countries in question.

Thus, the regulatory principles necessary for spectrum use in space are threefold: stability, predictability, and reliability. The viability of space-communication missions depends strongly on international harmonization of regulatory policy. Lack of adherence to these principles can lead to operation complications, business model disruption, and increased cost.

Regulatory problems can be exacerbated by the different constraints of terrestrial and satellite networks. Sharing is also an important issue for the commercial satellite industry. Although satellite industries have successfully shared spectrum with each other for years, it is more difficult to share spectrum with terrestrial services, especially because satellite services are more heavily regulated than their terrestrial counterparts.

Two issues concerning the use of 5G networks in terrestrial and satellite networks illustrate the kinds of problems that can arise with sharing spectra between satellite and terrestrial networks when regulatory principles are not consistently applied.

The history of the KA (28-gigahertz) band provides one example. First allocated for satellite use in 1995, the first broadband satellite designed for use of that band was launched in 2008. Now, there are hundreds of satellites, with millions of customers, using this very successful band, and it is very important to 5G service, especially in bringing service to developing countries that are difficult for terrestrial systems to reach. In 2015, the WRC (World Radiocommunication Conference) decided to not make the KA band available to terrestrial systems. After the 2015 conference, the U.S. decided nevertheless to allocate a portion of the KA band to terrestrial 5G systems; since that time, other countries have followed suit. There is concern that this topic may come up again in the 2019 WRC. If successful, this decision will strand billions of dollars of investment, stop innovation in space and block the ability for secure communication as well as the global reach that satellite systems require. International customers of U.S.-manufactured satellites are also concerned about the effects of changing regulations on their own systems. This kind of unpredictability and inconsistency in regulatory policy can render business models obsolete even before systems are launched.

A similar 5G-related problem has occurred with the V-band (millimeter-range wavelengths), which was first made available about a decade ago. Several companies, including Lockheed Martin, Boeing, and SpaceX, have licenses or applications pending for access to this band. But these companies were dismayed to discover, in preparation for the 2019 WRC that the U.S. policy for 5G offers protections for domestic use, but none for satellites, putting satellite systems at huge risk.

US technological leadership requires US regulatory leadership as well. The U.S. has considered itself a spectrum management leader over the last decade. However, that innovation has focused more on ways to make technological options more successful, rather than on exploration of more innovative *use* of spectrum. For the U.S. to remain a leader in this field, U.S. regulatory processes have to adapt to the broadening and intensifying uses of spectrum in space, 5G wireless, unmanned systems, and more. Despite the changes in spectrum use over the last 20 years, the decision-making process for spectrum use has not changed over the last 20 years. Perhaps it is time to consider whether U.S. regulatory policy is still adequate for today's needs. In theory, the National Telecommunications and Information Agency (NTIA), which is the voice of presidential priorities, and the Federal Communications Commission (FCC), an independent agency that is not responsible for implementing presidential priorities, share spectrum management. But in truth, authority for spectrum allocation rests with the FCC. Although there are consultations and coordination between the two agencies, the effectiveness of such coordination and communication is dependent on the personalities and cultures managers of the respective agencies; bifurcated management of this sort, without formal shared authority, seems less than ideal. Currently, different sets of space users report to two different authorities in two different branches of government: those in the scientific and national security sectors are under NTIA authority, and wireless and commercial users are under the FCC. This situation increases the difficulties of spectrum sharing between sectors. International decision-making becomes even more complicated; for international negotiations, the NTIA and FCC are used as merely technical advisors to the Dept. of State. At minimum, the current decision-making and authority structure for spectrum regulation seems outdated, and warrants review to incorporate the technological innovations and changes in spectrum usage over the last few decades.

In summary, to be successful in spectrum as a nation, the U.S. needs a predictable, stable, global regulatory regime and an international harmonized spectrum. Ms. Warren and Ms. Manner recommend a review of spectrum management authorities, in both domestic and international arena.

Adm. Ellis thanked the speakers for their informative presentation, especially for clarifying the criticality of spectrum issues for U.S. efforts in space. Adm. Ellis asked the speakers to offer some general principles that might define a perfect regulatory world. One goal worth some effort, offered Ms. Warren, would be creation of incentives for the original equipment manufacturers (OEMs) to build in sharing capability into an unknown environment, so that ubiquitous uses could co-exist in a trusted manner. Ms. Manner added the need for technology neutrality- that is, a recognition that each technology has its strengths and weaknesses, and usefulness in different contexts. As 5G and future technologies are introduced, it is important to provide certainty and resources for each of the technologies in question.

Dr. Schmitt congratulated the two speakers for their excellent treatment of a complex subject. He recommended to the UAG that they invite the current U.S. ambassador to the ITU plenipotentiary congress to educate the UAG further on these issues. He also pointed out one effort that has in the past contributed to international cooperation: an effort by Ambassador Mickey Gardner in the 1970's, in concert with industry, to create The International Telecommunications Training Institute. Still active decades later, and supported by Congress and the Department of State, the institute has made a tremendous difference, especially in our relationships with developing countries. Today, the majority of international attendees at ITU congresses have been trained at this institute.

Dr. Dittmar asked the speakers to characterize the urgency of regulatory reform and harmonization, especially as they relate to 5G. Ms. Manner and Ms. Warren replied that the problem is indeed very urgent and needs to be addressed sooner rather than later.

Mr. Ellis asked for clarification of the consequences of the inability of satellites to switch spectra in space, and wondered whether there are any technological solutions on the horizon. Ms. Warren replied that, in the near future, there are only regulatory solutions. But one reason for optimism is the fact that the space community collaborates very well; commercial satellite industries continue to collaborate well even as they compete with each other.

Returning to the speakers' opening remarks, Adm. Ellis asked whether spectrum users outside the U.S. may be using spectrum building blocks to block U.S. operations. Ms. Warren replied that competitors come in all shapes and sizes, and noted that several large space-faring nations are also large 5G players.

Public Comments and Closing Remarks

No public comments were received.

Adm. Ellis once again thanked the speakers for their excellent presentations. He adjourned the meeting at 3:00 pm MDT.

**APPENDIX A
Agenda**

**National Space Council
Users' Advisory Group**

**Public Meeting Agenda
April 8, 2019**

Broadmoor Hotel International Center
Colorado Springs, CO

- 1:00 – 1:30 **Opening Remarks & Committee Business**
Jim Ellis, Jr.
UAG Chairman
Selected Subcommittee Chairs with proposed Findings & Recommendations
- 1:30 – 2:15 **The Emergence of the Space Force**
Doug Loverro
Former Deputy Assistant Secretary of Defense for Space Policy
Marc Berkowitz
Vice President for Space Security, Lockheed Martin
- 2:15 – 2:50 **Space Spectrum: Challenge & Opportunity**
Jennifer Warren
Vice President for Technology Policy & Regulation, Lockheed Martin
Jennifer Manner
Senior Vice President for Regulatory Affairs, EchoStar
- 2:50 – 3:00 **Public Comment & Closing Remarks**
Jim Ellis, Jr.
UAG Chairman

All times Mountain Time

Appendix B

National Space Council Users' Advisory Group Membership

Adm. James Ellis, *Chair*

Retired 4-star Admiral, former head of STRATCOM

Buzz Aldrin

Apollo 11 Astronaut

Salvatore Bruno

President and CEO of United Launch Alliance

Wesley Bush

CEO of Northrop Grumman

Dean Cheng

Scholar at the Heritage Foundation

Col. Eileen Collins

Retired U.S. Air Force; Four-time Shuttle Astronaut

Steve Crisafulli

Former Speaker of the Florida House of Representatives

Mary Lynne Dittmar

President and CEO of the Coalition for Deep Space Exploration

Tim Ellis

CEO of Relativity Space

Marillyn Hewson

CEO of Lockheed Martin Corporation

Homer Hickam

Author of "Rocket Boys" and former NASA Marshall Spaceflight Center engineer

The Honorable Kay Ivey

Governor of Alabama

Fred Klipsch

Founder and Chairman of Hoosiers for Quality Education

Gen. Lester Lyles

Retired 4-star Air Force General and Chair of the NASA Advisory Council

Col. Pamela Melroy

Retired U.S. Air Force; Three-time Shuttle Astronaut; and former Deputy Director of the Tactical Technology Office, Defense Advanced Research Projects Agency (DARPA)

Dennis Muilenburg

CEO of the Boeing Company

Fatih Ozmen

CEO of the Sierra Nevada Corporation

G.P. "Bud" Peterson

President of the Georgia Institute of Technology

Eric Schmidt

Google and MIT Media Lab

The Honorable Harrison "Jack" Schmitt

Former U.S. Senator and Apollo 17 Astronaut

Gwynne Shotwell

President and COO of SpaceX

Bob Smith

CEO of Blue Origin

Eric Stallmer

President of the Commercial Spaceflight Federation

David Thompson

Founder and CEO of Orbital ATK

Pamela Vaughan

Board Certified Science Teacher

Mandy Vaughn

President of VOX Launch Company

Stuart Witt

Founder of Mojave Air and Spaceport, former Navy pilot, former Chairman of the Commercial Spaceflight Federation

David Wolf

Four-time Shuttle Astronaut and Physician

Appendix C Meeting Attendees

UAG Membership

Adm. James Ellis, *UAG Chair*
 Mr. Salvatore T. Bruno
 Dean Cheng (teleconference)
 Col. Eileen Collins (U.S. Air Force, ret.)
 The Honorable Steve Crisafulli (teleconference)
 Dr. Mary Lynne Dittmar
 Mr. Tim Ellis
 Mr. Homer Hickam (teleconference)
 Mr. Fred Klipsch
 General Lester Lyles (U.S. Air Force, ret.)
 Col. Pamela Melroy (U.S. Air Force, ret.)
 Mr. Fatih Ozmen
 Dr. G.P. (Bud) Peterson
 Dr. Eric Schmidt (teleconference)
 The Honorable Harrison Schmitt
 Ms. Gwynne Shotwell
 Dr. Robert H. Smith
 Mr. Eric Stallmer
 Ms. Pamela Vaughan
 Dr. Mandy F. Vaughn
 Mr. Stuart O. Witt
 Dr. David Wolf (teleconference)
 Brandon T. Eden, *UAG Executive Secretary*

Non-UAG Attendees

(transcribed from handwritten sign-in sheets; see Appendix E for original record)

Kyle Acierno	Ispace, Inc.
Andrew Acio	Jacobs Engineering Group
Meghan Allen	Sierra Nevada Corporation
Tim Anderson	Sierra Nevada Corporation
Larry Barrett	Space Foundation
Michael Barton	A.I. Solutions
Arthur (Bill) Beckman	Boeing
Paul Behan	NATCA (National Air Traffic Controllers Association)
Lutz Bertling	OHB
Jay Bookbinder	NASA-Ames Research Center
Natalia Borotkanych	EOS (Earth Observation System)
Jason Bourquet	NIWC (Naval Information Warfare Ctr)-Pacific

Ken Bowersox	NASA
Harriet Brettle	SGAC
Lou Brogden? (looks like Lew Bringle)	Gingrich 360
Jim Bridenstine	NASA
Anderson Bruscad	Brazilian Space Systems
Josh Brost	Relativity Space
Jeff Brown	Trax/Indiana
Jeff Burchfield	Sonalysts, Inc.
Daniel Burkett	VOX Space
Lisa Callahan	Lockheed Martin and Space Foundation
Tom Campbell	Harris Corporation
Chris Carpenter	ANSER (Analytic Services, Inc.)
Carol Carroll	NASA
Richard Carter	U.S. Strategic Command
Victoria Carter-Cortez	European Space Agency
Sarah Chapman	U.S. Air Force
Arfan Chaudry	UK Space Agency
Jim Chilton	Boeing
Dennis Clark	U.S. Air Force
Tom Codella	Evince Analytics
Richard Coleman	Space Transportation Association
Samantha Condie	Global Affairs Canada
Alberto Conti	Ball Aerospace
Ariane Cornell	Blue Origin
Ivan Couronne	Agency France-Presse (AFP)
Rebecca Cowen-Hirsch	Inmarsat Government
Tom Cremins	NASA
Todd Cress	Artel
Randy Cruz	NASA
Carl Cumm	ANSER (Analytic Services, Inc.)
Suzy Cunningham	NASA
Richard DalBello	Virgin Orbit
Hoyt Davidson	Near Earth, LLC
Craig Day	AIAA (American Institute of Aeronautics and Astronautics)
Clementine Decoopman	SGAC (Space Generation Advisory Council)
Samu Eshima	SGAC (Space Generation Advisory Council)
Pascal Faucher	CNES (Centre national d'études spatiales: French National Centre for Space Studies)
Gen. William Fraser	Sierra Nevada Corporation
Martin Frederick	Northrop Grumman Corporation
Sally Frodge	Federal Aviation Administration (FAA)
Marco Fuchs	OHB
Dearn Fulmer	The Mitre Corporation
John Gaine	NASA
Sumedha Garud	NASA Ames SimLabs
William Gattle	Harris Corporation
William Gerstenmaier	NASA
Suzanne Gillen	NASA

G. Gillinger	U.S. Air Force – 14 th Air Force
Adam Gleason	A28 Design Services
Jodi Goldberg	EchoStar
Alexandra Gravereaux	Astroscale Ltd.
Loren Grush	<i>The Verge</i>
Jon Harrison	Dept. of State (Oceans and Environmental and Scientific Affairs)
Brooke Hart	Sierra Nevada Corporation
Phil Heaver	Lockheed Martin Corporation
Curtis Hernandez	National Space Council
Catherine Hofacker	<i>Aerospace America (AIAA)</i>
Clint Hunt	United Launch Alliance
Christopher Ingraham	International Space Station U.S. National Lab
Peggy Irwin	Ball Aerospace
Arthur Jacques	NASA- Goddard Space Flight Center
Edgar Johansson	LASP (Laboratory for Space and Atmospheric and Space Physics, University of Colorado Boulder).
Nathan Johnson	Astro Executive Consulting, LLC
Rafael Jordá Siquier	Open Cosmos
Jordan Joseph	Relativity Space
Janet Karika	NASA
Michael Kelly	U.S. Strategic Command
Matthew Kerley	ION Communications
Maik Kammermann	Bundeswehr
M.G. Kenny	SGAC (Space Generation Advisory Council)
Trevor Kilpatrick	United Launch Alliance
Paul Korell	NIWC
Swetha Kotichintala	SGAC (Space Generation Advisory Council)
Chris Kunstadter	AXA XL
Jim Kuzma	Space Florida
Bhavya Lal	IDA STPI (Science & Technology Policy Instit.)
Cornell Lashbrook	Space Foundation
Cody LeBlanc	Office of Rep. Ken Buck (Colorado 4 th district)
Glen Liebig	NASA- Goddard Space Flight Center
Amanda Lomas	Sierra Nevada Corporation
Michael Long	U.S. Nuclear Regulatory Commission
Douglas Loverro	Loverro Consulting, LLC
Kimberly Lusk	Relativity Space
Makenzie Lystrup	Bell Aerospace
Kate Maliga	Aerojet Rocketdyne
John Marshall	Rumsford Engineering
Cindy Martin-Brennan	ISS National Laboratory
Wade McElroy	VOX Space
Shawn McEniry	LSINC Corporation
Nate McIntyre	NASA
Naomi McGill	Rainbow Centres
Sean McClain	HQ AFSPC (Air Force Space Command)

Kevin McLoughlin	UK Space Agency
Jolene Meidinger	NASA
Fritz Merkle	OHB SE
Brian Miller	[undecipherable]
Erin Miller	National Cybersecurity Center
Kyle Montgomery	Air Force Research Lab
Peter Montgomery	Jacobs Engineering Group
Jim Morhard	NASA
Mark Mozena	Planet
Santos Munoz	NRO (National Reconnaissance Office), U.S. Air Force
George Nelson	NASA
Neal Newman	NASA
Marcus Nichols	United Launch Alliance
George C. Nield	Commercial Space Technologies, LLC
Carson Owens	U.S. Air Force
Tim Owens	U.S. Air Force - NORAD
Eren Ozmen	Sierra Nevada Corporation
Carson Owens	US Air Force
Regina Peldszus	German Aerospace Center (DLR)
David L. Pierce	NASA
Arnau Pons	SGAC (Space Generation Advisory Council)
Tasman Powis	Princeton University
Richard Pym	Dept. of State
Lon Rains	Northrop Grumman Corporation
William Readdy	NASA (ret)
Camilo Reyes	SGAC (Space Generation Advisory Council)
Josh Rickey	Northrop Grumman Corporation
Jana Robinson	Prague Security Studies Institute
Rob Ronci	Secure World Foundation
Louis Rousmaniere	Planet Labs
Antonino Salmeri	SGAC (Space Generation Advisory Council)
Jose Santos	Brazil DAO (Dept. of Defense)
Luigi Scatteia	PwC Advisory France
Kristin Shahady	Ball Aerospace
Manny Shar	Bryce Space and Technology
Simon Shuham	Blue Origin
Jeray Simms	L3 Technologies
Stewart Smith	US Air Force
Jordan Sotudeh	NASA/JPL
Ed Spitler	Artel
Antonio Stark	SGAC (Space Generation Advisory Council)
Johnny Stephenson	NASA
Olga Stelmakh-Drescher	International Institute of Space Commerce
Timo Stuffer	OHB
Richard Sypniewski	ENPULSION
Gary Talbott	no affiliation given
Will Theunissen	Facebook Connectivity Lab
Eric Thoemmes	Lockheed Martin Corporation

Kathryn C. Thornton	Space Foundation Board
Jeff Trauberman	VOX Space
Demos Tsairides	NASA
David A. Turner	U.S. Dept. of State -OES/SAT (Oceans and International Environmental and Scientific Affairs/ Space and Advanced Technology)
W.B. Tutt	Space Foundation Board of Directors
Maj. Gen. José Vagner Vital	CCISE-Brazil (Space Systems Coordination and Implementation Commission)
David Van Buren	L3 Technologies
Julie Van Kleeck	Aerojet Rocketdyne
Scott van Sant	U.S. Strategic Command
Natalia Vargas-Cuentas	INTI-Lab (Image Processing Research Laboratory)
Gary F. Vaughan	No affiliation given
Xuyen T. Vuong	Artel
John Wagner	Sierra Nevada Corporation
Bob Walker	Moonwalker Associates
Taylor Weeks	NASA
Amber Whittington	U.S. Air Force Space Command (AFSPC)
Ben Wilking	Atec, Inc.
Leslie Wilkins	MEDB
Josh Wolny	Secure World Foundation
Nathaniel Yiitalo	U.S. Army Space and Missile Defense Command
Halil Yonter	Raytheon
Zheng Wenjing	[indecipherable]
5 additional attendees with indecipherable signatures	

Teleconference attendees

Baker Allen	Office of the Governor of Alabama
Gale Allen	American Society for Gravitational and Space Research
Eric Berger	<i>Ars Technica</i>
Emily Boster	Lockheed Martin
Kent Bress	NASA HQ
Laura Canadee	Public
Keith Cowing	NASAwatch.com
Nicolas Cummings	SpaceX
Kate Cron-Miller	Jacobs Engineering Group
Laura Delgado-Lopez	NASA
Elizabeth Esther	NASA
Karen Feldstein	NASA
Richard Fischer	NASA - Marshall Space Flight Center
Mary Floyd	Electrosoft
Valerie Green	Ligado Networks

Jamison Hawkins	Lockheed Martin
Janelle Kasper-Wolfe	Marshall Space Flight Center
Theodore Kronmiller	Attorney, Great Falls, VA
Michael Lapidus	SpaceX
James Lochner	Universities Space Research Association
David Lubar	Aerospace Corporation
Jim Luckner	Universities Space Research Association
Tim Maclay	OneWeb
Meredith McKay	NASA
Laura Montgomery	Ground Based Space Matters
David Newman	Unaffiliated
Bob Pauljola	Lockheed Martin
Diane Rausch	NASA headquarters
Steve Rhyne	NuGen
Mary Beth Saffo	Electrosoft/NASA
Frank Slazer	Aerospace Industries Corporation
Marcia Smith	SpacePolicyOnline.com
Joel Wallace	NASA-Marshall Space Flight Center
Jeremy Westmoreland	NASA Marshall Space Flight Center
Ashley Wilkins	US House of Representatives
Rodney Womack	NASA
Philip Zion	General Dynamics
Ann Zulkosky	Lockheed Martin
5 additional registrants with indecipherable information	

Appendix D
List of Presentations

Opening Remarks – Mr. Brandon Eden and Adm. James Ellis

Exploration & Discovery Subcommittee Report – Gen. Lester Lyles

National Security Subcommittee Report – Adm. James Ellis

The Emergence of the Space Force – Mr. Doug Loverro and Mr. Marc Berkowitz

Space Spectrum – Ms. Jennifer Warren and Ms. Jennifer Manner

NAME	ORGANIZATION
Melissa Helms - Drescher	JPL
Rafel Jordi Siqueira	Open Cosmos
Carson Owens	USAF
David L. Pierce	NASA
Stewart Smith	USAF
Josh Brest	Relativity
Suey FRODGE	FAA
Victoria Carter - Carter	European Space Agency
Christopher Ingeln	ISS National Lab
Curtis HERING	NATIONAL SPACE COUNCIL
Jordan Joseph	Relativity Space
Naomi McOill	Rainbow Centres
Richard Carter	USSTRATCOM
Eve Owen	SNG
Erin Miller	Natl Cybersecurity Center
William Readdy	NASA (ret'd)
Nathaniel Yitralo	USA SMDC
Douglas Lowery	Lowery Consulting, LLC
Julie VanKleeck	Aerofjet Rocketyne
Louis ROUSMANIERE	PLANET LABS
Pascal Fancher	CNES
Ben Walker	Moonshot
Jim Clift	BOEING
Boyle Beckman	Boeing

NAME

ORGANIZATION

Norman Johnson

Astro Executive Consulting LLC

Richard Ryan

Dep of State

Martin Frederick

Northrop Grumman Corporation

Tom Ours

USAF - N224D

G Gillinger

USAF - 14 AF

Hall Venter

2entoon

Eric Thoenmes

LMCO

Arthur Jacques

NASA GSFC

Zheng Wenjing

DTI MTRN Hospital

HOF DAVIDSON

NEAR EARTH LLC

Fritz Meekle

OHB SE

Kim Lusk

Relativity Space

Ivan Goufoune

AFP

Scott Van Sant

USSRATCOM

George C. Nield

Commercial Space Technologies LLC

Josh Rickett

Northrop Grumman

Meghan Allen

SNC

Eren Ozmen

SNC

Gen Fraser

SNC

John Wagner

SNC

Tom Anderson

SNC

Liam Bennett

USSF

Suzy Cunningham

NASA

Lw Bizle

Gugrak 360

NAME

ORGANIZATION

Jeff Brown

Trax / Indiana

Michael Kelly

USSTRATCOM

Kathryn C. Thomas

Space Foundation Board

Jim Kuzma

Space Florida

John Wagner

SIERRA NOVATA Corp

Kevin McLaughlin

UKSA

JANA ROBINSON

PSSI

Andrew Airo

JAMES

Clint Hunt

UCLA

Demos Tsarides

NASA

1st Lt Col - RAN

ITA

Don Kopp

NINCC

Michael Barton

aisolutions

JAY BOORISARDER

NASA / ARC

LON RAINES

NORTHROP GRUMMAN

Arthur Choung

UKSA

Michael Long

USNRL

Cindy Martin-Brennan

ISS National Laboratory

Cornell Lashbrook

Space Foundation

Bhanyamal

IDA STPI

Tom Codellz

EVINCE

Dennis Clisc

USAF

Marco Fucias

OHB

Lute Berling

OHB

Kyle Aiemu

NAME

ORGANIZATION

Simeelha Garud

NASA Ames Sim Lab / ASC

Gary F Vaughan

Kyle Montgomery

Lisa Callahan

Catherine Hofacker

Glen Liebig

Chris Kunstader

Phil Heaver

Peter Montgomery

Brian Miller

XLIYEN (XT) VUONG

Ed Spitzer

Tosul Choi

Jodi Goldberg

WELL THIEUNHSSIEU

Loren Grush

Josh Wolny

Regina PELDSZUS

Shawn McEniry

William GATTLE

DEAN FULMER

Mark Morn

DAVID A. TURNER

Mark Kemmerman

Air Force Research Lab

LM + Space Foundatn

Aerospace America - AIAA

NASA GSFC

AXA XL

Lockheed Martin

Jacobs

Cleveland

ARTEL

ARTEL

Artel

Echostar

FCL

The Verge

Secure World Fund

DCR Space Administration

LSINC, Corp

HARRIS Corp

THE MITRE CORP.

PlanX

SPACE-DES/SAT

Bundeswehr

NAME

ORGANIZATION

NAME	ORGANIZATION
Matthew Kerley	IGN communications
Kate Malign	AR
Jonathan STEENLAND	NCU
Makenzie Lyshay	Dall Aerospace
Cody LeBlanc	Cong. Ken Buck CO-OH
Marus Nichols	ULA
Jason Bourgnat	NIWC-Pac
Suzanne Gillen	NASA
Johnny Stephenson	NASA
JEFF BURNEBY	SonARISTO
Timo Stuffle	OUB
ALBERTO CONTI	BALL
John Marshall	Rusford Eng.
Adam Gleason	A2V Rossier Services
Ben Wilking	Atec
Sweetha Kotichintala	SGACU
Wade McEiron	Uox Space
Elly Azzet	AKSR/JR SEC DA
Trevor Kilpatrick	ULA
Stephane Baume	CU Boulder
Chris Carpenter	ANSER
Youngwon Choi	Anderson UCLA
Tom CAMPBELL	HARRIS

NAME

ORGANIZATION

Richard DalBell

Virgin Orbit

Jos Santos

Brazil BAO

Haniel Boeltle

SGAC

DANIEL BURKETT

VOX SPACE

Rich Spawicki

EXPULSION

Ariane Coanell

Blue Origin

REBECCA COWEN-HIRSCH

INMARSAT

RANDY CRUZ

NASA

Amanda Lomas

Sierra Nevada Composites

Brooke Hart

SNC

ANTONIO STARK

SGAC

MG Kenny

SEAC

PAUL BEHAN

NATCA

CRAIG DAY

AIAA

Sarah Chapman

Air Force

Jon Havin

DOS

Rob Rossi

Secure World Foundation

AMBER WHITTINGTON

AFSPC

Edgar Johnson

LASP

Tasman Pocius

Pomona University

Carl Cummins

ANSER

NAME

ORGANIZATION

Jeray Simms

L3 Technologies

DAVID VAN BUREN

L3 Technologies

M. Gen Jose Vagner Vital

CCISE - BRAZIL

Ltcol Anna Gorn Tolkin

USAF

William Gerstman

NASA

Kim Bowers

NASA

Geo Nelson

MAEII

Antonin Solner

SGAC

Kristina Shahadey

Ball

WB Judd

Specifm BOD

Camilo Reyes

SGAC

Natalia Vargas

INTI-Lab

Santos Munoz

NRO

Samu Estima

SGAC

Carol Carroll

NASA

ALEXANDRA GRAVEREAUX

ASTROSCALE

Clementine DEOSMAN

SGAC

Leslie Wilkins

MEMB

LUIGI SCATTEIA

PXC

Natalia Protokanyan

EAS

Pengxi Wu

Ball Aerospace

Jordan Lotuleh

NASA/JPL

NAME

ORGANIZATION

164 ANDERSON BRUSCAP

BRAZILIAN SPACE SYSTEMS

165 Simon Shaker

Blue Origin

166 Manny Shar

Bruce Space & Technology

167 Sean McQueen

HQ AFSPC

168 SAM CONNIE

Global Affairs Canada

169 CAROL ALBERT

170 Arnau Pons

Space Generation Advisory Council

171 Jeff Trauberman

VOX Space

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