

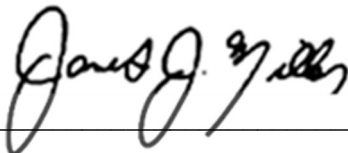
**NATIONAL SPACE COUNCIL
USERS ADVISORY GROUP
4TH MEETING**

**OCTOBER 21, 2019
COURTYARD BY MARRIOTT
WASHINGTON, DC**

MEETING MINUTES



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



Mr. James J. Miller, Executive Secretary

Executive Summary

The National Space Council (NSpC) Users' Advisory Group (UAG) was launched in 2017 to provide counsel and develop recommendations from a space users' perspective. On October 21, 2019, from 1:00 to 5:00 p.m., the UAG held its fourth meeting at the Courtyard by Marriot, Washington Downtown / Convention Center, Shaw Ballroom, 901 L Street NW, Washington, DC 20001. The meeting was open to the public, and also available telephonically and via WebEx. The meeting was chaired Admiral James O. Ellis, Jr. with James J. Miller (NASA Headquarters) as the new Executive Secretary.

The UAG was briefed on "Experiences and Issues of the National Positioning, Navigation, and Timing Advisory Board" by Dr. Bradford Parkinson (1st Vice Chair, National Space-Based PNT Advisory Board). He described the development of the U.S. Global Positioning System (GPS), how the PNTAB is contributing to its operation, and offer candid advice on his experience with the FACA process. Dr. Parkinson noted that the PNTAB Charter and operation shares many characteristics with the UAG, and specific foci of the PNTAB have substantial synergies with the UAG.

This briefing was followed by reports from the subcommittees and public comment. The UAG voted on and approved the following recommendations:

1. The NSpC should write a Space Policy Directive concerning Science, Technology, Engineering and Mathematics (STEM) education in the United States (U.S.) with the intent to prepare the future space industry workforce.
2. The NSpC should direct the UAG to define the scope of a study to be conducted by the National Academy of Public Administration, reviewing U.S. regulatory jurisdiction and governance (domestic) v. a goal of technology leadership across spectrum related technology sectors. The study should also address an assessment of the current U.S. governance model for spectrum v. alignment with multiple national technological leadership and capabilities priorities.
3. The NSpC should direct the UAG to develop a white paper, outlining and scoping a study of the means to establish and maintain a U.S. Strategic Space Propellant Reserve modeled on the U.S. Strategic Petroleum Reserve (SPR). The white paper should identify variables important to establish reference requirements, such as: (a) the size and location of initial reserves needed to stimulate sufficient infrastructure to support an eventual \$1 Trillion space economy; (b) technical means; (c) identification of markets that could be enabled; and (d) models for funding, and others. It is anticipated that a detailed study undertaken by the National Academies of Sciences, Engineering and Medicine would follow initial scoping by the UAG.
4. NASA should provide a briefing to the UAG on their technology roadmap in light of Artemis and the Moon to Mars program, and, if the UAG deems it is warranted, fund a brief external review of the roadmap.

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Call of Order, Announcements

James J. Miller, Executive Secretary / Primary DFO, UAG

Mr. James Joseph Miller, Executive Secretary, National Space Council Users' Advisory Group (UAG), called the fourth meeting of the UAG to order at 1:00 p.m. He noted the 70th International Astronautical Congress (IAC) was being held right across the street. The IAC was kicked-off by Vice-President, Mike Pence, and it is therefore very appropriate that we are all here together now to further support some of the work activities that he spoke about. The UAG was relaunched in 2017 to serve the NSpC, which the Vice-President Chairs, and so today we are gathered to continue providing counsel and developing recommendations that contribute to meeting NSpC goals from a user's perspective. Mr. Miller noted he serves as the Executive Secretary of the UAG, supporting our Chair Admiral Ellis, and all of our expert members around the table. For more information about how the Space Council and UAG are organized, please take a quick look at the Agenda booklet, which is also available on the NASA website. All of the members have been nominated by the federal agencies and departments that comprise the NSpC, and were subsequently appointed by the NASA Administrator. They are serving based on their individual expertise, or to represent sectors of the American space industry. As a whole, the UAG is intended to be balanced and comprehensive. UAG members are formally categorized as Special Government Employees, or SGEs, or Representatives. SGEs are subject to Federal Ethics laws, and so we remind everyone that if a potential conflict-of-interest arises during our deliberations today, that you recuse yourself from that discussion for the record and not engage. It is important to note that the UAG is an advisory committee established under the Federal Advisory Committee Act, or FACA. As such, all our deliberations are open to the public. Such committees have served our nation since President George Washington sought the advice of such a group during the Whiskey Rebellion of 1794, and the contributions made ever since are impressive and diverse. Please note that, although this is a public meeting, we do ask that observers not interrupt members. Since today we are going to talk about space, and not whiskey, it should be a little easier to maintain the peace. There is some time on the agenda for public input, and the NASA UAG website does have an e-mail address where questions can be posed. Also, in compliance with FACA, deliberations and supporting material become part of the public record, and meeting minutes will be made available within 90 days. In closing, note that the "virtual public" is online right now, listening to us with great interest. Mr. Miller then turned the meeting over to the UAG Chair, Admiral James Ellis, Jr., USN, Retired.

Opening Remarks

Adm Ellis, Chair, UAG

Admiral Ellis noted his appreciation for the board members attending in person as well as those connected internationally by phone and WebEx. He noted the meeting is taking place on the shoulders of the IAC. Many board members also have responsibilities associated with the IAC. He thanked J.J. Miller for organizing the meeting and bringing together everyone's expertise. He also thanked Dan Dunbar for his exceptional American Institute of Aeronautics and Astronautics (AIAA) team that has assisted in organizing the UAG at this venue. Today there are 20 of 27 members participating, so a quorum exists to address the action items. Vice President Pence has characterized this group as exceptional as it brings expertise from many different perspectives. The members of each Sub-Committee (SC) have met many times to deliberate. However, rather than drafting voluminous reports the group will present their key facts and recommendations. The UAG charter is broad and full of opportunities. The NSpC has reviewed the charter and is making changes to improve the working of this group. The revised charter is currently under final review and will be made public and posted once the review is complete. The purpose of today's meeting is: (1) Dr. Parkinson (Vice Chair, National Space-based Positioning, Navigation, and Timing Advisory Board) to deliver a message describing the development of the U.S. Global Positioning System (GPS), how the PNTAB is contributing to its operation, and offer candid advice on his experience with the FACA

process; and (2) the UAG will continue to work, review recommendations, and discuss what will be presented to the NSpC. Adm Ellis introduced Dr. B. Parkinson and read his bio. Adm Ellis also noted that Adm Allen, former U.S. Coast Guard Commandant and current Chair of the National Space-Based Positioning, Navigation, and Timing Advisory Board (PNTAB), is also present in the auditorium.

Experiences and Issues of The National Positioning, Navigation, and Timing Advisory Board

Dr. Bradford Parkinson – 1st Vice Chair, PNT Advisory Board

Dr. Parkinson began by noting he and Buzz Aldrin had been classmates at MIT. He explained his briefing would focus on highlighting an on-going threat to GPS users, and will go into some technical depth. Most of the PNTAB activities have focused not just on GPS, but also on other systems that supplement GPS. GPS is available worldwide and provides accuracies within a fraction of an inch. However, its signals are also a very weak signal. The received signal power is less than a millionth of a billionth of a Watt. There are over 3 Billion GPS receivers in use across planet, and GPS is taken for granted worldwide with hundreds of applications. The vast majority of users don't even realize how much GPS is doing for them. The economic value of GPS is enormous, and a recent study estimated the value to the U.S. economy to exceed \$65 Billion, and this figure doesn't even factor in safety-of-life considerations. GPS has become an essential part of U.S. infrastructure, as declared by Department of Homeland Security (DHS).

If a user can't get GPS, what can they do? Most users are in a quandary because they don't even know who to call. The PNTAB is there to protect those that may not know how GPS works or how to protect it. The objective of the PNTAB is to assure PNT for all, and represent hundreds of millions of users worldwide. The PNTAB works similar to the UAG. It reports to a PNT Executive Committee (PNT EXCOM), which consists of the deputy secretaries or equivalents from departments and agencies of the U.S. government. The PNTAB also has international members and, yet, has still been able to run things smoothly. International participation has also given us a knowledgeable source of information.

An example of on-going PNT activities is our coverage of a grave threat to GPS, in particular to high precision users. Years ago, a company obtained license to transmit satellite-to-ground signals within the Mobile Satellite Services (MSS) frequency band, which happens to be adjacent to the GPS (and other Global Navigation Satellite System, or GNSS) L1 frequency band. At some point they realized the power of the signal coming from space is low and cannot support high data rates, as required by applications such as broadband, and thus they decided to instead rely on the ancillary terrestrial component (ATC) within the MSS band, which had been originally intended for secondary use, as its primary form of operation and provide service primarily through high power ground-to-ground transmissions. The reason for this is, understandably, money. This would increase the value of the spectrum allocation by \$10 Billion, and perhaps even \$20 Billion. The question, however, is whether this harms GPS users. In 2010 the company tried to get the Federal Communications Commission (FCC) to accept this change mode of operation, but the PNTAB noticed this and raised concerns within the U.S. government. We wrote a letter to the FCC and were able to slow the process of adjudication. It also turns out that, according to a legal filing from an investor, the company advocating for this change in license may have been already aware there was a serious interference problem. The government conducted extensive testing and, as a result, the company said it would decrease the transmitting power to 10 Watt, but it is not entirely clear to us what the tower spacing will be. However, they have indicated they intend to support 5G and this has certain implications. The received wireless radiation from a 5G network is, in fact, 30 times stronger than 4G LTE systems. This in turn requires much closer spacing between transmitters. For instance, to protect all High-Performance GPS receivers, at 9.8 Watts the tower spacing would need to be at least 20 km, which is far greater than the ~ 200 meters spacing that would be required to support 5G.

Therefore, the PNTAB is strongly recommending the disapproval of this proposal. There is a long list of high precision (and high productivity) applications at risk. Some have argued that only a subset of GPS users are at risk, and that perhaps their value to the U.S. economy is not as important as the benefits of 5G, but this is not true. In fact, a study was recently conducted in the United Kingdom (UK) on what would happen should GPS not be available for up to five days, and was found to be \$1.5 Billion economic loss to the UK per day.

Bottom line, the PNTAB has defined a tolerable degradation radius, which is a noise floor risen by 25%. This translates to a 1dB margin. This issue has been going on for 10 years, and we still don't have a clear denial that this will not be allowed to happen. It should be noted that these concerns are not just from the PNTAB. All U.S. government testing has confirmed this problem (see Department of Transportation Adjacent Compatibility Band Tests). Therefore, the PNTAB is asking for U.S. government support for our recommendation to: (1) reject the latest 10 Watt proposal, which does not meet our goal to protect; and (2) apply PNTAB Adjacent Band Compatibility methodology for any future proposals.

This issue also applies to the majority of space systems. These spectrum issues also apply to the UAG. The majority of space-based systems rely on relatively weak radio signals from space. Most of these signals are placed in radio bands of "like-use". Commercial pressure on many bands comes from a desire for greater (terrestrial) data bandwidth – e.g. hi-def movies. There is a temptation to reduce adjacent-band restrictions. Therefore, vigilance is needed because once band use is allowed, it is unlikely it would be reversed.

However, there has been some recent good news regarding use of Global Navigation Satellite Systems (GNSS). The FCC has finally approved the reception of Galileo (Europe's GNSS) signals in the U.S., something long advocated by the PNTAB. This allows for non-federal U.S. receive-only stations to operate within specific signals of the Galileo GNSS without obtaining a license or grant for market access. When using foreign GNSS signals we are in violation of FCC regulations. This approval grants a waiver for use of Galileo signals. The PNTAB hopes this will extend to other GNSS.

Finally, looking back over past years the PNTAB has had many other achievements, such as development of specifications for GPS and GNSS Space Service Volume (SSV) [Editor note: the volume of space between 3000 km altitude and GEO altitudes], implementation of laser retro-reflectors on GPS III, and using NASA global GPS/GNSS monitoring networks and differential GPS corrections. This is important to space users because GPS is already being used for booster guidance, station keeping, and even trans-lunar flight capability. This relies on using the GPS side-lobe signals. We did not expect this back when GPS began, but NASA experiments have recently shown that GPS signals (main and side lobe signals) can be successfully tracked up to over halfway the distance to the Moon. It should be note, however, that while useful the use of GPS side lobe signals (in addition to the main lobe) is not currently protected either through requirements or specifications.

As for how the PNTAB operates, its tone was set by its first chairman: Dr. J. Schlesinger. It meets twice per year, including one day for preparation and two days of public meetings. The topics are assigned by the PNT EXCOM and also self-assigned. This presents many opportunities as well as issues. It is important that a charter allow to bring full expertise to bear in tasks both assigned and self-assigned. The issue of Conflicts of Interest (COI) has been a challenge at times. The PNTAB has also had an educational dimension as government principals, while bright, often need to be education on the technical specifics. Another challenging issue has been that ultimately power is within the budget.

In conclusion, the PNTAB charter and operation shares many characteristics with the UAG. Specific foci of the PNTAB have substantial synergies with the UAG.

Q&A:

Adm Ellis: In the initial response regarding the threat to GPS, did you act independently or did you coordinate with the government?

Dr. Parkinson: In the longer term we have coordinated with the U.S. government. However, initially Dr. Schlesinger went straight to the FCC, which was like poking a stick in a hornet's nest. We don't mind the heat. Following this we have worked through all the normal channels.

Adm Ellis: Is the decision still pending? Why is there a Damocles sword still hanging?

Dr. Parkinson: From standpoint of advocacy there is a lot of money sitting on table. This is understandable and if it were up to us, we would give them spectrum, but just not there. This is analogous to starting a rock band next to a retirement home. There may also be an additional 'embarrassment factor' within the FCC.

Dr. Cheng: Do you foresee similar issues abroad? Is there a PNT Advisory Board equivalent you can work with?

Dr. Parkinson: I believe the international community is now starting to become more aware of this. The commercial pressure is enormous, and unfortunately the L-Band is the sweet spot for many things. The crisp answer is that there is no coordination group like us in Europe. The UN International Committee on GNSS (ICG) has done some work on this. We have suggested something similar to PNTAB, where users can have a voice, but they have not yet responded. Hopefully at the ICG-14 meeting in December, to be held in Bangalore/India, I can scare the heck out of them. A key issue we need to raise is that while GPS cellphone could handle this type of interference, high accuracy (and high value) users cannot.

Dr. Dittmar: The UAG Economic Development SC is looking at spectrum broadly. We are going to brief this afternoon, and give our finding regarding spectrum. One of the key issues we want to look at is spectrum management, and we are happy to have the PNTAB on board so we can reach out for advice and would also like to work out an opportunity for further follow up with the PNTAB.

Adm. Ellis: The UAG has been approaching this more broadly. We are going to propose this as an effort that needs to be undertaken, and also understand how we have even gotten into a situation like this one.

Dr. Parkinson: That is an excellent recommendation. We will do all we can to help you. [Adm Thad Allen, PNTAB Chairman, in the audience nodded in agreement]. There are other on-going needs and applications where weak signals from space assets are problematic if you try to add power on the ground. GPS users have been generally passive. Most don't even know who to call for help. This could help address this.

Dr. Wolf: Are there other bands where 5G could be implemented?

Dr. Parkinson: Yes, most 5G uses are fine, the problem is when they try to do this next to a quiet neighborhood such as GPS.

James J. Miller: I also have the PNTAB portfolio for NASA, and want to reiterate what Dr. Parkinson has stated. For example, this 5G company has indicated it wants to set up 40,000 base stations, and we have found this will even adversely impact satellites in Low Earth Orbit (LEO) doing applications such

as radio occultation. There is only one GPS, but there are many broadband solutions. If we can't even protect GPS, then perhaps we can't protect anything. On a more positive point, you all have a United Nations (UN) booklet "The Interoperable GNSS Space Service Volume" that shows an analysis done by all PNT service providers. What's interesting is that at first no one in the UN even knew what the SSV was, but right now all PNT services providers are looking into making GPS available even beyond the SSV [note: the upper limit of the SSV is at Geosynchronous Orbit altitude] into Cislunar space. This also has other benefits such as allowing closer packing of Geostationary Orbit (GEO) satellites and, thus, enabling more 'prime real estate' within the crowded GEO belt.

Exploration & Discovery Subcommittee Report

General Lester Lyles, USAF, retired – Subcommittee Chair

Gen Lyles noted that we should include Buzz Aldrin in the SC membership.

The focus of our SC is to assess current efforts and identify areas for further work by NASA on defining a Lunar exploration architecture to accelerate the return of Americans to the Moon. Depending on the information NASA will provide we may consider recommending an independent evaluation of the lunar exploration architecture.

Our proposed approach is for the UAG to form a temporary special Task Force to assess the NASA architecture approach with the objective to illuminate and understand the following: (1) NASA's specific vision and goals to return Americans to the Moon by 2024; (2) assumptions and alternatives examined; (3) target features and elements included in the architecture; (4) a notional 2024 campaign; (5) acquisition strategy and timeline; and (6) risk factors and potential mitigations.

Since the last UAG meeting we've had numerous meetings and telecons with NASA. Key discussions included determining the proposed Task Force membership, assessing the need for 'Non-Disclosure Agreements', and determining the content required regarding NASA's architecture.

Our plan is to ask NASA to brief the SC so we can ask questions related to the items briefed (while avoiding proprietary information or information relating to source selection), and if there are such specific proprietary/source selection concerns we can convene a subset of the E&D subcommittee (preferably UAG / SGE members) to discuss those details.

Once this proposed Task Force completes its effort, we'll provide a brief assessment of the 2024 Lunar Architecture to the full UAG, and then brief the NSpC. We also intend to review the 'Regulatory and Policy' recommendations from the NASA Advisory Council for information to the UAG and/or endorsement to the NSpC. We'd like to brief the NSpC before its next meeting.

Q&A:

Adm Ellis: do you have an estimate of the timeline for this effort to be undertaking?

Gen Lyles: We have several weeks (through November) to do this. We'll try to get it by then. We need a whole day to brief this, and then we'll ask for a full UAG meeting in December.

Adm Ellis: Col Collins and other astronauts have been briefed on an updated architecture. The organization NASA presented to was association of space explorers (an international group of astronauts).

Col Collins: The particular meeting I attended was briefed by current astronaut. It was excellent to be with someone that described orbits for Artemis, Gateway, etc. It is important for us to understand thoroughly the technical side. This is what Gen Lyles is asking for his SC.

Gen Lyles: That's what we need.

Col Melroy: There are sensitivities around acquisition issues. Sometimes it's a specific technology, or an element to a specific technology. The sensitivity is in the specific acquisition plan. That is very hard for industry to do.

Adm Ellis: While we know what architecture will be, we may not get the analysis that went into that.

Col Buzz Aldrin: If you want to go to the Moon, you go from orbit around earth to orbit around moon. The problem is that the launch vehicle we have can't get the crew there with sufficient maneuver capability. Therefore, we should back off to an orbit that can be easily adjusted, such as going into a near rectilinear orbit (as Gateway) and wait there. I believe we don't need a structure permanently there. What we need is a trans-orbit craft that goes up and down to the moon, perhaps one with solar electric propulsion.

Gen Lyles: We want to understand the analytics behind current architecture, and why it agrees or not with what we're discussing today.

Fatiz Ozmen: I'd like to comment on the last question. When the UAG reviews the architecture, should we also look at the requirements side of it? What is the requirement? Sustainability is one of the objectives. What does that mean? That will determine if we do one shot or go multiple times. We want to know the circumstances behind architecture. This is not clear at present.

Adm Ellis: The context/vision is important, not just redoing Apollo. We want to establish the preparation of requirements for moving onto Mars. All this needs to be part of this architecture. The context described by Gen Lyles is broader than that.

S. Bruno: If we're going to the Moon and come back, then it's clear a simpler architecture can achieve that. If we want to go to Mars, then we need to study the effects on humans being outside Earth's magnetic shield, etc. We must include all that in the study.

Dr. Dittmar: We also need to know the priority of those requirements.

Gen Lyles: We also need to review the regulatory and policy recommendations from the NASA Advisory Council (NAC).

Adm Ellis: That's an important issue, but it also touches every SC. I'm wondering if rather than study by every SC, perhaps we should instead have a specific SC that interfaces with the NAC. Would a one stop shop be more efficient?

Gen Lyles: I'm open to discuss this.

Adm Ellis: I think we need to figure out the elements that are important to each SC, and more clearly assess the impact of the findings from the NAC.

Col Melroy: I like idea of starting with the EXCOM.

Adm Ellis: Agreed, we need to bring this to EXCOM.

Gen Lyles: I agree with you. I'll put a package together for the full EXCOM within the next couple of weeks.

Adm Ellis: We'll work into next EXCOM meeting.

Col Buzz Aldrin: Point of clarification ... we just assumed we're going to south pole of Moon. I think we need some organization that really makes a detailed study of the north pole vs. the south pole. I have a copy of a report that I think needs to be evaluated by someone capable to make a decision.

Adm Ellis: I've seen that paper too. That's the kind of question we can ask as we review some of the assumptions going into analysis.

Col Buzz Aldrin: I gave a copy to Jim Greene.

Outreach & Education Subcommittee Report

Colonel Eileen Collins, USA Retired, Subcommittee Chair

Col Eileen Collins noted that Homer Hickam has just been added to the membership.

The scope of our work is as follows: (1) explore and recommend ways to improve our country's education system in an effort to strengthen technical expertise which will allow the U.S. to retain its preeminent global space programs; and (2) collaborate with space program stakeholders to ensure the NSpC has access to the information and conditions that contribute to strong U.S. leadership in space. The subcommittee will chronicle the interactions between its members and the stakeholder community.

Since the April 2019 UAG we've had the following meetings:

- July 17: National Conference of State Legislatures (NCSL), which focused on issues regarding K-12
- July 18: Event at Purdue University
- Aug 1: Lewis-Burke: The NASA-University Enterprise, which focused on government-university collaboration
- Sep 18: Committee review/discuss/prepare findings and recommendations
- Oct 10: Office of Science and Technology Policy and NASA Office of STEM Engagement, including the administration's focus on a five-year STEM education plan.

Our SC has one recommendation: writing a Space Policy Directive regarding STEM education in U.S. to prepare future space industry workforce.

We have four observations regarding on the NCSL:

- We have found that higher education is often inadequate for preparing STEM teachers of future. Often universities do not prioritize their educational programs. We must treat education as high performance colleges. We have also noted dropouts from other programs opt for teaching.
- U.S. K-12 educational performance has declined over last decades. Although spending has doubled since 70s, the reading performance of students has not increased at all.

- There is disparity among universities to retain 1st year engineering students. Just because a student struggles it does not mean he or she cannot be a successful engineer.
- Finally, in K-12 there is a disparity in the quality of education. The quality should be equally successful to student wherever they are. Unfortunately, there are significantly large number of areas where students don't have access.

Therefore, we believe a space policy directive will help States to improve their STEM education.

Regarding the Lewis-Burke event, our major finding is that the successful NASA-University collaboration can be used as a model for other government agencies to emulate. Internships, apprenticeships, etc., can be helpful if done earlier in careers. Some leading applications include AI, advanced propulsion, etc.

OSTP wrote and released in Dec. 2018 the report, "Charting a Course for Success: America's Strategy for STEM Education." We believe this report is a good starting point for a successful space policy directive

In summary, we're not recommending that a large amount of money be spent. We think that, instead, we can help local leaders to understand issues and apply to how they do things.

Q&A:

Pamela Vaughn: We're asking teachers to provide supply of engineers, but I see difficulty in retaining educators that provide STEM. I think we need to consider this too.

Mandy Vaughn: We've had a pretty robust discussion within the SC. Another item to consider is not just being able to recruit STEM, but also through entire ecosystem of the workforce.

S. Bruno: Has your SC also thought about issue of women attrition rate from STEM higher than men?

Col Collins: We don't have statistics. That is something we could ask universities for. Some women have said a reason is that they don't feel they're not part of culture and feel being 'left out'.

S. Bruno: Regarding doctoral candidates, they're increasingly non-US students. Can we encourage them to move to U.S. citizenship? Do we invest more in educating our own?

Adm. Ellis: I've seen presentations on this. I almost believe this is a national security imperative. This is something that perhaps could start in national security SC.

Gwynne Shotwell: Who is going to provide the data for council to provide recommendation?

Col Collins: I'd like to put that out for discussion. Let's be an idea group, but as far as implementation of this that's up for discussion.

Marilyn Hewson: That is something we could wrestle with.

Adm. Ellis: We need to identify credible sources for this. This is an opportunity for discussion.

Fred Klipsch: I think we have expertise in this group to discuss. We need to keep positive and discuss how to improve quality of education.

Dr. Dittmar: They draw on science board data.

Eric Stallmer: Just last month we met at Arizona State Univ. The work done there is no less than transformational. The retention rate for engineers was like 84%, some of highest in the country. They're also working on outreach with other universities.

Col Collins: We're aware with what Univ. Arizona is doing. We want to get their example out.

Tim Ellis: I'd be interested to see what actually inspires the next generation. A fear of mine is agile development is occurring in other industries (IT, etc.), but not in STEM.

Adm Ellis: There's been lot of focus over decades. The question is how we translate that into effective policy. Should we vote today on recommendation?

Col Collins: If my committee agrees, yes, we could vote.

Fatiz Ozmen: Many of us (agencies, companies, etc.) have we have our own STEM initiatives, and I don't know if they're talking to one another.

Adm Ellis: Do we have the ability to do the data collection an analysis? I'm not sure we can do. But there are folks in government that can do this. A policy directive would be a whole of government approach.

Col Collins: We could use the current administration five-year plan as a starting point.

Maryllin Hewson: Maybe one of the workstreams of plan is the space workforce. We need to make sure we have a spotlight on space workforce.

Dr. Wolf: Do we not have an education representative on the NSpC itself?

Adm Ellis: I don't believe Dept. Education is represented.

[The group voted on the recommendation. The board overwhelming voted yes. There were no nays.]

Space Policy and International Engagement Subcommittee Report

Dr. David Wolf – Subcommittee Chair

Dr. Wolf noted that Dr. Scott Pace has given us a good set of initial steerers. He noted the scope of this SC is provide findings and recommendations on how the U.S. can most effectively continue to lead international space efforts so as to advance both U.S. national and ally/partner interests, broadly construed. In particular, address how the U.S. should respond to growing international and potentially adversarial space capabilities.

Since the last UAG meeting, the SC has focused on the following:

- Obtaining approval of Finalized Terms of Reference.
- Acquiring initial background material (Dept. of State / United Nations - related).
- Obtaining a briefing from the Dept. of State, Bureau of Arms Control, Verification, and Compliance (Eric Desautels), on U.S. efforts with the UN Office of Disarmament Affairs, Conference on Disarmament (CD), in developing international recommendations for Transparency and Confidence Building Measures in Outer Space Activities (UN TCBM's).

- Reviewing work by the Dept. of State, Bureau of Oceans and International Environmental and Scientific Affairs, efforts with the UN Committee on the Peaceful Use of Outer Space (UNCOPUOS) in enhancing the Guidelines for the Long-term Sustainability of Outer Space Activities. It should be noted that although voluntary, these form comprehensive and effective norms of advantage to National Security, Commercial, and Civil / Exploration Space.

We anticipate public discussion on how these and other measures:

- Become fully adopted by the UN
- Be adjusted as the implementation of the Space Policy Directives (SPD's) progresses
- Although these measures are "voluntary," they will contribute to advancing an attractive and globally inclusive Space Enterprise. They will also prevent adversarial and hostile uses of outer space.
- Promote "norms of behavior" promoting peaceful high value uses of space by the international community as opposed to adversarial purposes
- Mitigate the vulnerabilities, promote verification, and defeat deception
- Establish references to determine response to adversarial space activity
- Prevent unintended negative consequences (misperceptions, etc.)

We need to make inputs as we would see the space policy directives are the government document of all. We want a situation where it's more attractive to pick the friendly way and use space to improve human quality of life instead of carrying an arms race in space. Just having rules written in red already mitigates vulnerabilities because we understand the situation, promotes verification techniques, and defeats deception. Our subcommittee is open to suggestions from the public: hq-uag@mail.nasa.gov

Q&A:

Adm Ellis: Progress is being made in some areas. It's obviously a multi-dimensional challenge as with many diplomatic efforts. How those dynamics play out is something this SC is looking at. The reality is that there are now more active nations in space than at any other time in history. There are some things we can do, and we have been successful in changing some international behaviors. There are areas SC may want to explore beyond their current activities.

Col Buzz Aldrin: The term Space Exploration Enterprise Alliance as used by VP Pence is a good term. Alliance implies a friendly and collaborative approach.

Adm Ellis: Do you see that as an organization with some structure, or a coalition of the willing and able?

Col Buzz Aldrin: Alliance means you're there together for space exploration, but you may not necessarily be in a coalition.

Adm Ellis: An alliance has more of a challenge, but also more of an opportunity.

Dr. Dittmar: There are more than 70 space companies in that effort.

Dr. Cheng: An alliance is much more predictable, i.e. we'll be there no matter what. ISS is more of a space coalition as Buzz said. Earlier when listening about GPS, I'm not sure anyone can say with any confidence that PNT systems, no matter how important, will be left free and clear. In the middle we have a range of new states, they're new to space in every sense in terms not just industry, but also laws

and treaties. It would behoove the U.S. to establish openings to these new players and show how to operate within the voluntary guidelines that have been indicated.

Dr. Wolf: As written, on confidence measures (which are very inclusive) almost every country is a signatory to them.

Col Collins: Regarding space situation awareness, if two satellites are going to collide, who is supposed to use their propellant to move out of the way?

Dr. Wolf: We are addressing that. But this presupposes a central depository at the UN.

Col Collins: It seems to me we're not moving fast enough, as is the case with the ISS and the main risk for loss of crew being debris.

Adm Ellis: It's still a coalition in the sense this is voluntary. I would state that an alliance does not guarantee either everyone will be on the 'same sheet of music'.

Col Buzz Aldrin: We've just had a national policy change resulting in Artemis 2024. But this subcommittee is space policy and international engagement. What could be more pertinent that ISS and how long is it going to be up there and what is our policy for phasing it out or replacing it with more specialized laboratories at a more convenient orbit?

Dr. Wolf: Next time we'll talk more on sustainability.

Economic Development & Industrial Base Subcommittee

Dr. Mary Lynne Dittmar & Eric Stallmer – Subcommittee Co-Chairs

Eric Stallmer noted one of the challenges / opportunities is the spectrum issue, and how we have dealt with this. It has been a bit of an albatross given enormity of this. Our activities have been as follows:

- Held four telecons to develop Terms of Reference, identify potential topics of focus, and develop a work plan
- Consulted with National Space Council staff
- Consulted with several stakeholders
- Discussed plan with SC members most recently during telecon on 3 October; updated the TOR to reflect a change in scope
- Provided inputs to a study of spectrum management and allocation
- Recommended the National Academy of Public Administration to conduct a study
- Followed up with UAG Chair Admiral Ellis on 10 October to finalize approach

We find the current regulatory situation for spectrum management is absent. The lack of certainty, stability, and reliability creates significant challenges to U.S. technology leadership. The U.S. governance model for spectrum needs to be reviewed in order to ensure alignment with 21st century needs and objectives. It would also be helpful to get involved with other groups such as the PNTAB.

Our recommendation is that the NSpC direct the UAG to define the scope of a study to be conducted by the National Academy of Public Administration, reviewing U.S. regulatory jurisdiction and governance (domestic) v. a goal of technology leadership across spectrum related technology sectors. The study should

also address an assessment of the current U.S. governance model for spectrum v. alignment with multiple national technological leadership and capabilities priorities.

Dr. Dittmar: In terms of meeting with other groups, we could ask for a yay/nay on convening a day meeting to get into a room with these people, who have tremendous knowledge on use of spectrum. We need to convene a meeting to discuss how to approach this, and define the scope of issues we think need to be addressed.

Adm. Ellis: This is a process review, not a technical issue with spectrum allocation. Perhaps it's better to ask for a scoping one-day study on what's required.

Dr. Dittmar: Yes. The only caveat is we may need to have separate discussions, perhaps an AM discussion on the PNT Spectrum and a PM discussion on another spectrum topic.

Adm Ellis: I would like to propose a vote on findings and recommendations. Want to make sure we have all data before handling off.

[The group voted on the recommendation. The board overwhelming voted yes. There were no nays.]

Eric Stallmer continued with his briefing. He noted that, beyond spectrum, the SC is also looking at the development of a space ecosystem. To this effect, the SC held three exploratory telecons to discuss issues and identify scope regarding economic development of LEO and Cislunar space, and the region between them. We identified several of focus for potential findings and recommendations (one has been closed, and the others are ongoing). We discussed the plan with SC on Oct. 3, including USG initiatives to stimulate space economy, and a proposal for Space Strategic Propellant Reserve. We followed up with UAG Chair Admiral Ellis on 10 October to finalize our approach.

The overarching enabler for commercial activity is affordable transportation. Earth to Cislunar transportation costs \$10,000 - \$50,000 per kg today. The driving cost in-space transportation is propellant. The majority of a rocket's mass is fuel. However, propellants sourced in space would avoid the cost of lifting from Earth's gravity well. Between 60 and 70% of energy required to reach cislunar destination is spent on Earth-to-LEO. Therefore, the USG could stimulate a large space economy by facilitating in-space propellant availability. This could include ice mining, propellant manufacture, and storage. This would be akin to the U.S. Strategic Petroleum Reserve. The USG could similarly establish a requirement to create and maintain Strategic Reserve of Propellant sourced in space.

Adm Ellis: Should we vote on supporting this added study?

Dr. Wolf: This is a very good idea.

Col Melroy: You may also want to add something about governance, i.e. who will manage and how.

Dr. Cheng: I suggest at least consider adding an annex to discuss security. Anything large in orbit (such as a propellant depot) becomes a target.

Col Buzz Aldrin: We should consider in what form do you want to store propellant. I would recommend this be in form of water, with nuclear reactor for advance hydrolysis into hydrogen and oxygen.

[The group voted on the recommendation. The board overwhelming voted yes. There were no nays.]

Technology & Innovation Subcommittee Report

Colonel Pamela Melroy, USAF, Retired – Subcommittee Chair

The scope of the SC is to: (1) review new technologies and new applications of technology, as well as business innovation practices and new business models; and (2) make recommendations relevant to these topics on national policy, technology and operations architectures, and inter-department and agency coordination. Since the last UAG the group had four administrative/preparatory telecons to: develop Terms of Reference, identify potential topics of focus, and develop a work plan. We distributed available technology roadmaps for awareness/review and held one-on-one discussions between chair and individual members to refine the issues.

The SC's topics of focus are to: (1) review USG space technology roadmaps to uncover synergies, overlaps, and inconsistencies that could be better aligned for national impact; and (2) assess space data as a U.S. government capability vs buying as a service. The first topic is difficult as some roadmaps are classified. On the second topic, increasingly there are commercial opportunities where they collect data and sell it to customers. An issue that is particularly timely is that of space situation awareness data. Earth Observation hit this point 10 years ago when it suddenly became more available, and transformed over past years and became more sophisticated.

The technology roadmap review is an urgent matter because of the aggressive timeline to return to the Moon. The SC has noted that under SPD-1 and direction from Vice President Pence, NASA has updated its Moon to Mars planning. Under the Artemis program, the plan is to return to the surface of the Moon by 2024. However, NASA's last technology roadmap update was in 2015 with review by National Academies in 2016; roadmap and review closely aligned with exploration plans at the time (that is, across the NASA enterprise, not just the human exploration). Therefore, we recommend that NASA update their technology roadmap in light of the Artemis and Moon and to Mars program, provide a briefing to the UAG, and fund a brief external review. A roadmap with the new priorities, and matching the new timeline, will ensure timeline is met and resources used adequately. [Editorial note added on January 9, 2020: it turns out NASA is updating its Technology Roadmap]

I would love to draft a recommendation for a vote. The important words are updating a tech roadmap, which doesn't mean NASA also needs to publish it. Also, we don't need roadmap across entire enterprise, just key technologies for Artemis and going onto Mars.

Having said that, we're open for discussion.

Q&A:

Adm Ellis: If you get a briefing, and find it has been updated and adequate, would the request for external review no longer apply?

Col Melroy: I have highest respect for UAG, but I'm not sure we have complete coverage especially in the technology areas that would be addressed. Perhaps we should say 'if required'. My expectation is there may be some areas we are not qualified to discuss.

Fatiz Ozmen: We should ask NASA first to see what they have. That should perhaps be first question we should ask prior to making a more formal recommendation.

Col Melroy: If we have to wait to come back, we run into problems because of the critical timeline. My preferred option is to include that in the recommendation. If anything, we can use words such as 'if necessary'.

Dr. Wolf: How does this fit with the architecture trade studies we discussed earlier?

Col Melroy: That's been our biggest point of anxiety, that is, which roadmap are we comparing to. I think the timing has worked out nicely for our Exploration SC, and I think this issue dovetails perfectly with it. The timing we want to discuss is whether we have architecture briefing before we get the technology roadmap briefing.

Adm Ellis: Viewing technology as independent gives us another bite at the apple. Thus, it is good to keep this under Col Melroy's SC instead of Dr. Wolf's.

Maryllin Hewson: Do we perhaps want to see what it is first?

Col Melroy: I recommend NASA brief the SC on tech program and, if necessary, further recommended by UAG to fund further review.

[Adm Ellis called for a vote. The board overwhelming voted yes. There were no nays.]

National Security Subcommittee Report

Admiral James Ellis, Jr., USN, Retired – Subcommittee Chair

The DFO for our group is Jolene Meidinger. We have broad spectrum of talent and skills. No gaps in it. Most have top level clearances.

The scope of our work includes reviewing national security considerations relevant to National Space Policy and National Security Space Strategy, such as: (1) space systems, space capabilities, and space architecture; (2) future national security space requirements; (3) system resiliency, robustness, and interoperability; (4) interagency collaboration/cooperation; and (5) the evolving national security space threat environment. The scope also includes making recommendations on national security considerations to the UAG affecting coordination, cooperation, and technology and information exchange among the civil, national security, commercial, and international space sectors. Finally, we assist other UAG subcommittees in reviewing classified elements within the scope of their efforts.

Recent activities include receiving a classified informational briefing from the Office of the Secretary (OSD) of defense on the status of preparations to establish a United States Space Force when approved by Congress and in full compliance with the law. The briefers included: Deputy Secretary of Defense Stephen Kitay, Planning Task Force lead Major General Clint Crozier, and participating representatives from OSD, the Intelligence Community (IC), and the Joint Staff. The briefing included both the strategic context as well as specifics in its organization. The strategic context includes understanding the strategic environment, defining the problem we're trying to address, and what is the new approach we need to address it. The organization aspect included the space force's role and mission, functions and authorities, key relationships, a transition plan into the Space Force, and its personnel and budget. Key takeaways (at the unclassified level) include:

- The focus is on real warfighting capabilities
- Space systems are increasingly important and increasingly vulnerable

- We must protect critical infrastructure, guard against unnecessary bureaucracy, and be both capable AND cost effective
- The Space Force will operate within the Department of the Air Force (akin to DON/USMC)
- DoD is ready pending Congressional approval and consistent with law, with an incremental approach from 2020 to 2025
- DoD welcomes UAG review after legislation on establishment is approved

The Schriever Wargames also remain an incredibly valuable forum for improving the integration of the commercial space sector into realistic U.S. and allied military planning and operations. We have learned many lessons from the 2019 wargame.

The supports a “whole of government” approach to ensure that commercial entities are well understood, integrated and leveraged into war fighting planning and doctrinal debate. This only becomes more important as we embark on the creation of the Space Force – this whole of government discussion may result in suggested changes to authorities for the new acquisition process and personnel, requirements definition and possibly planning and budgeting guidance or legislation to ensure the Space Force provides the war fighter with the appropriate space-based or space-“backed” services our cutting edge technological warfighters and systems require to project lethal force.

The current topic of focus is to assess and recommend options for the organizational structure of the uniformed Space Force, to include a future Department of the Space Force. In addition to implementation timelines, authorities, and skills required, areas of potential consideration include organizational/functional relationships, rank structure, officer/enlisted ratios, and other personnel considerations. The UAG would have necessary information and access, as appropriate, to the Department of Defense and other relevant organizations. Also, we propose to participate in the growing number of venues (including classified) focusing on National Security Space and use these opportunities to gather perspectives, identify potential issues, and provide inputs to the National Space Council. We also want to work with other UAG Subcommittees and consider the issues that may lie at the seams of national security and commercial /civil space.

Mandy Vaughn: The integration of a commercial cell into the wargame was very important. We appreciated opportunity to participate. We thank space command for opportunity.

Dr. Cheng: Because space is new domain for conflict, there is huge area of uncertainty.

S. Bruno: It should not surprise us there is a role to protect commercial operations in space.

Adm Ellis: We have recommendation under consideration (see below) based on what Mandy and Dean brought back. This will require more review.

“The UAG National Security Subcommittee supports a “whole of government” approach to ensure that commercial entities are well understood, integrated and leveraged into war fighting planning and doctrinal debate. This only becomes more important as we embark on the creation of the Space Force – this whole of government discussion may result in suggested changes to authorities for the new acquisition process and personnel, requirements definition and possibly planning and budgeting guidance or legislation to ensure the Space Force provides the war fighter with the appropriate space-based or space-“backed” services our cutting edge technological warfighters and systems require to project lethal force.”

Public Comment and Closing Remarks

[Adm Ellis opened the microphone for public comment as per FACA guidelines]

Mike Helton, Helton Associates, asked consideration has been given to protection of Earth from an asteroid impact.

Adm. Ellis said that was a legitimate concern. This has not been a specific topic in the SC, but it is clearly a topic of increasing interest.

Adm. Ellis thanked Dr. Bradford Parkinson for his presence and participation. In closing, he stressed the primary importance of spectrum, which had multiple use in cis-lunar navigation. Adm. Ellis briefly restated each subcommittee major points. He thanked all for their participation and gaveled the meeting adjourned at 5:18 p.m.

Wrap Up

Adm Ellis: I look forward to work with PNTAB in months ahead. Thanks to you (Dr. P.) for perseverance. Takeaway is spectrum and use in space is important.

Summary of Approved Recommendations:

1. The NSpC should write a Space Policy Directive concerning STEM education in the United States with the intent to prepare the future space industry workforce.
2. The NSpC should direct the UAG to define the scope of a study to be conducted by the National Academy of Public Administration, reviewing U.S. regulatory jurisdiction and governance (domestic) vs. a goal of technology leadership across spectrum related technology sectors. The study should also address an assessment of the current U.S. governance model for spectrum vs. alignment with multiple national technological leadership and capabilities priorities
3. The NSpC should direct the UAG to develop a white paper, outlining and scoping a study of the means to establish and maintain a U.S. Strategic Space Propellant Reserve modeled on the U.S. Strategic Petroleum Reserve (SPR). The white paper should identify variables important to establish reference requirements, such as: (a) the size and location of initial reserves needed to stimulate sufficient infrastructure to support an eventual \$1T space economy; (b) technical means; (c) identification of markets that could be enabled; and (d) models for funding, and others. It is anticipated that a detailed study undertaken by the National Academies of Sciences, Engineering and Medicine would follow initial scoping by the UAG.
4. NASA should provide a briefing to the UAG on their technology roadmap in light of Artemis and the Moon to Mars program, and, if the UAG deems it is warranted, fund a brief external review of the roadmap. Note: (1) the roadmap does not need to also be published; and (2) we don't need roadmap across entire NASA enterprise, just key technologies for Artemis and going onto Mars.

[The meeting was adjourned at 5PM]

Appendix A: Agenda

National Space Council Users Advisory Group

Public Meeting Agenda
October 21, 2019

Courtyard by Marriott/Washington Downtown
Convention Center/Shaw Ballroom
901 L Street NW
Washington, DC 20001

- 1:00-1:15 CALL TO ORDER, OPENING REMARKS, & MEETING GOALS**
James Joseph “JJ” Miller – UAG Executive Secretary
Admiral James Ellis, Jr., USN, Retired – UAG Chair
- 1:15-2:15 EXPERIENCES AND ISSUES OF THE NATIONAL POSITIONING,
NAVIGATION, AND TIMING ADVISORY BOARD**
Dr. Bradford Parkinson – 1st Vice Chair, PNT Advisory Board
- 2:15-2:45 EXPLORATION & DISCOVERY SUBCOMMITTEE REPORT**
General Lester Lyles, USAF, Retired – Subcommittee Chair
- 2:45-3:30 OUTREACH & EDUCATION SUBCOMMITTEE REPORT**
Colonel Eileen Collins, USAF, Retired – Subcommittee Chair
- 3:30-3:45 BREAK**
- 3:45-4:15 SPACE POLICY & INTERNATIONAL ENGAGEMENT SUBCOMMITTEE
REPORT**
Dr. David Wolf – Subcommittee Chair
- 4:15-4:30 NATIONAL SECURITY SUBCOMMITTEE REPORT**
Admiral James Ellis, Jr., USN, Retired – Subcommittee Chair
- 4:30-4:45 TECHNOLOGY & INNOVATION SUBCOMMITTEE REPORT**
Colonel Pamela Melroy, USAF, Retired – Subcommittee Chair
- 4:45-5:15 ECONOMIC DEVELOPMENT & INDUSTRIAL BASE SUBCOMMITTEE
REPORT**
Dr. Mary Lynne Dittmar and Eric Stallmer – Subcommittee Co-Chairs
- 5:15-5:30 PUBLIC COMMENT**
- 5:30 ADJOURN**

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

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

Marilyn 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

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

Kathy Warden

Chairman, CEO, and President, Northrop Grumman Corporation

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: Sign-In List

UAG Membership

James Ellis, *UAG Chair*
Buzz Aldrin
Salvatore Bruno
Dean Cheng
Eileen Collins
Mary Lynne Dittmar
Tim Ellis
Marilyn Hewson
Fred Klipsch
Lester Lyles (via Telecon)
Pamela Melroy
Fatih Ozmen
Gwynne Shotwell
Bob Smith
Eric Stallmer
David Thompson
Pamela Vaughan
Mandy Vaughn
Stuart Witt
David Wolf
James J. Miller, UAG Executive Secretary

Non-UAG Attendees

Barbara Adde
Bretton Alexander
Jeffrey Auerbach
Frank Bayer
Bill Beckman
Jamil Castillo
Burton Catledge
Jim Chilton
Robert Crane
Alexandra Doten
Al Feinberg
Tim Frazier
Martin Frederick
Dana Goward
David Grossman
Cindy Hasselbring
Mike Helton
Tim Hughes
Christopher Ingraham
Janet Karika
Janet Kavandi

Rick Leach
Cindy Martin-Brennan
Chris Mindnich
Steven Mamru
Katie Nau
A.J. Oria
Scott Pace
Joel Parker
Bradford Parkinson
Andrew Robinson
Eric Thoemmes
Jeffrey Travberman
David Turner
Paola Villores
Ivy Williams-Malone
Anne Zulkosky

Appendix D: List of Presentations

Opening Remarks – Adm James Ellis

Experience and Issues of the US PNT Advisory Board – Dr. Bradford Parkinson

Exploration and Discovery Subcommittee Report – Gen Lester Lyles

Outreach and Education Subcommittee Report – Col Eileen Collins

Space Policy & International Engagement Subcommittee Report – Dr. David Wolf

National Security Subcommittee Report – Adm James Ellis

Technology and Innovation Subcommittee Report – Col Pamela Melroy

Economic Development and Industrial Base Subcommittee Report – Dr. Mary Lynne Dittmar & Mr. Eric Stallmer