SCOTT HARRIS: So I always enjoy the afternoon session of a conference because you know who the hardcore folks are. [laughter] They have the lunch and still come back when the weather's nice.

For those of you who don't know me, I'm Scott Harris. I am NTIA's most recent hire; maybe its oldest as well. And I am a Senior Spectrum Advisor in Alan's front office. I am thrilled after 28 years of working with NTIA to actually be part of NTIA. And I'm excited to be able to join you all here this afternoon.

By their presence here this afternoon, whether in person or by video, our speakers actually reflect several things, I think. First, how important spectrum policy is. The second is how blissfully bipartisan it generally has been. And the third is how global it is, and, perhaps even when we hear NASA's presentation, how interplanetary it's becoming.

With all of that in mind, our first afternoon remarks are from Senator Ben Ray Luján, who is the of the Subcommittee on Communications, Media and Broadband of the Senate's Committee on Commerce, Science and Transportation. And if you think that was easy to say!

Senator Luján has long been a champion of the expansion of broadband internet access to all of America's rural, tribal and remote areas, many of which are in his home state of New Mexico. He knows that effectively managing federal spectrum is essential, not only to broadband access, but also to ensure that all Americans have access to emergency and other critical services. Senator Luján understandably could not be here with us in person this afternoon, but he sent a video message to share with us.

BEN RAY LUJÁN: Hello, everyone, Senator Ben Ray Luján here. I want to thank you Administrator Davidson and all of you at NTIA for inviting me to speak to you at your Spectrum Policy Symposium. This is an important event highlighting NTIA's role as the lead agency on

federal spectrum policy. Your engineers and policy professionals are critically important when it comes to tech and telecom, and I want to say thank you to each and every one of you.

This event and the work you do every day has never been more important. Federal management of natural resources is critical in areas like spectrum, where we need public involvement. Spectrum is a limited natural resource and the challenges are many. We have spectrum challenges across industry, government, technology, policy and politics. And when we don't find solutions, a policy challenge can easily become a national crisis.

Federal licensed and unlicensed spectrum serves as a foundation for the broadband network that enables those of us in New Mexico and across America to communicate with friends and family, work and learn from our homes and utilize telehealth services.

The national security of the United States depends on how we manage this essential resource. Spectrum helps first responders fight floods, wildfires and other natural disasters to keep us safe and to keep them safe. It even allows us to see the deepest stars and explore the origins of our universe through the very large array in central New Mexico and through radio telescopes around the world.

NTIA's efforts are critical in each of these areas, and I couldn't be more excited about the work you're doing and the innovations you're creating. I commend Chairwoman Rosenworcel and Administrator Davidson and your staffs for coming together to write an updated memorandum of understanding that structures how your two agencies resolve spectrum challenges. This MOU reaffirms NTIA and FCC's roles as the sole agencies in charge of managing our spectrum resources. It increases coordination and addresses many of the challenges for managing bands that have a significant federal agency stakeholder.

Finally, the MOU promotes better coordination and emphasizes evidence-based policymaking which is something we need more of in Congress. As a member of the Senate Commerce Committee and Chairman of the Subcommittee on Communications, I'm working with Chair Cantwell and Ranking Member Wicker to get you the resources you need to do your jobs effectively.

And I stand with you and your mission to expand broadband internet access and adoption in America, in every corner of our beautiful country, expand the use of spectrum by all users, and ensure that the internet remains an engine for continued innovation and economic growth.

Thank you, and have a great conversation. [applause]

SCOTT HARRIS: I think Senator Luján's remarks reinforce our goals of working together with other government agencies, and all stakeholders generally, to leverage spectrum allocation and regulatory decisions to promote ubiquitous internet access.

Now, in line with the bipartisan nature of all of this, our next keynoter is Senator Roger Wicker, who is the Ranking Member of the Senate Committee on Commerce, Science and Transportation. Senator Wicker, who also is providing his remarks via video, is a strong proponent of unleashing innovation through spectrum policy and of leveraging the expertise of the FCC and the NTIA to solve complex spectrum policy matters.

ROGER WICKER: Hello, I'm US Senator Roger Wicker. It's an honor to address this distinguished group of leaders and stakeholders working to advance spectrum policy. I hope this year's symposium proves to be informative and fruitful.

Spectrum is the lifeblood of wireless communications. US spectrum policy has helped drive unprecedented growth in the wireless economy. It has yielded prosperity and enhanced quality of life for our entire nation.

Increased commercial access to spectrum enables innovators to develop new technologies impacting every area of our lives, including remote work, telemedicine, education and public safety. But there's clearly a need for much more of this invisible resource.

As Ranking Member of the Senate Commerce Committee, I've been working on a range of proposals to free up more spectrum for both federal and commercial use. In less than 11 days, the FCC's authority to auction spectrum will expire. Reauthorizing this auction authority is critical to keeping up with demand for wireless services and maintaining our global leadership in technology.

I appreciate the bipartisan efforts in the House to extend auction authority for 18 months. A short-term extension along these lines would give Congress time to develop a long-term spectrum pipeline, bands to be auctioned for commercial use. This would, of course, generate revenue for the Treasury while funding other Congressional priorities. It is noteworthy that Congress has never allowed the FCC's auction authority to lapse since it was first granted in 1993.

Failing to act now would weaken our leadership and inject significant uncertainty into our 5G future. I hope my Democratic colleagues can agree on a path forward to extend the FCC's auction authority before the end of the month. Maintaining our lead in spectrum technology will also require better coordination between NTIA and the FCC.

Last year, I introduced the bipartisan Improving Spectrum Coordination Act, which require both agencies to update their memorandum of understanding governing spectrum coordination and

planning. I was pleased to see the NTIA and the FCC released an updated MOU last month, which included a commitment to work collaboratively to ensure we are utilizing spectrum effectively, and in a way that will encourage continued investment and innovation. Although this MOU is consistent with my legislation, it is still important to pass the Act so that we don't go to another 20 years without an update of the MOU.

The MOU also serves as an important tool to ensure that both federal and non-federal equities are represented in the spectrum policymaking process. As a member of both the Commerce Committee and the Armed Services Committee, I've had the chance to work with stakeholders representing a variety of spectrum policy viewpoints and objectives.

I believe it is crucial that we develop a spectrum pipeline, as well as an overarching national spectrum strategy which would help build consensus among federal and non-federal interests so that our entire national interest is served.

Finally, Congress should look at modernizing the Spectrum Relocation Fund. This would ensure federal agencies have the resources they need to fulfill their missions while also preparing for federal spectrum to be repurposed for commercial use.

These are a few of my priorities on the Commerce Committee, and I'm hopeful that Republicans and Democrats can come together in the weeks and months ahead to meet our nation's spectrum needs.

Thank you, all, for allowing me to speak. And please enjoy the rest of the symposium. [applause]

APRIL McCLAIN-DELANEY: Thank you very much. I'm April McClain Delaney. I'm the Deputy Assistant Secretary at the Department of Commerce for Communications, and also the Deputy Administrator at NTIA.

So our next speaker made history four years ago by becoming the first woman elected to an ITU leadership position in its 157-year history. Her vision at the ITU is clear – driving meaningful connectivity to the 2.9 billion people who remain unconnected and broadening partnerships to accelerate digital transformation.

Elected in 2018 as the Director the ITU's Development Bureau, she has demonstrated results-oriented and inclusive leadership. Doreen has an unmatched record of bringing the needs of the developing world to the forefront and bolstering the ITU's record and outreach to women and youth.

Her visionary Partner2Connect initiative, which NTIA proudly supported by giving broadband expertise and knowhow, launched at the WTDC conference in Rwanda last June an resulted in raising $26 billion – I have to say that again, $26 billion – in pledges for connectivity. Truly visionary.

And we never forget to mention she's a former NTIA staffer.

Doreen is also running to become the ITU's first Secretary-General as a woman at the Plenipotentiary held later this week; in fact, ten days from today is the election. It will be held in Bucharest, Romania. She has the full endorsement of the US government, and I've been personally privileged to spend the last few months working with an interagency team on bilats to garnish[sic] votes. And along the way, I've become a Doreen superfan. Really, I love her.

A trusted leader, dedicated to connectivity and innovation, she prioritizes spectrum policies. We're grateful to hear from her today, so please welcome, virtually, Doreen Bogdan-Martin. [applause]

DOREEN BOGDAN-MARTIN: Ladies and gentlemen, what a pleasure it is to join you today to deliver the international keynote at this year's NTIA Spectrum Policy Symposium in the company of so many distinguished experts.

I want to take a moment to thank the NTIA team, and especially April McClain-Delaney, for inviting me to be here. And I want to congratulate you as well on having bought together such an outstanding lineup of speakers.

I don't need to tell any of you that the past two-and-a-half years have been tough. But if we've struggled, just imagine how much harder it has been for the billions of people around the world still totally unconnected from the internet's power to deliver information, vital goods and services, schooling and, let's never underestimate it, the human collaboration and connectedness that binds us all together.

As we approach the upcoming ITU Plenipotentiary conference, and soon thereafter the WRC 2023, we need to work hard. We need to work hard to connect the unconnected, to build partnerships and collaborations to help deploy that connectivity, and then build the digital and workforce skills to best utilize that connectivity; to have an ITU that excels as an institution and is hardwired for the future and responsive to the needs of member states.

The pandemic has left us in no doubt whatsoever about the critical importance of connectivity and communication to the lives and the livelihoods of every person on this planet. Yet, by ITU's latest estimates, a third of the world's population still remains totally offline. If that weren't already an F, we know that many hundreds of millions more are obliged to settle for digital access that's far too slow, far too expensive or simply too hard to reach for it to play any meaningful role at all in improving their lives.

It's not just access to connectivity, but it must be at a sufficient speed to be meaningful. In order to be able to meaningfully engage, it also has to be affordable to its users. Despite ITU's own figures pointing to a COVID bump that brought an additional 800 million online in just two short years, recent reports show that the cost of connectivity for the world's poorest communities is moving in the wrong direction. The mounting monthly cost of basic broadband means that some 75 million people can now no longer afford to be online. That's a catastrophic trend that we need to work fast to reverse.

In a rapidly digitizing world, a global connectivity gap that shuts out well over a third of humanity is a situation that we can simply no longer tolerate. If we truly mean to deliver on the sustainable development goal promise to leave no one behind, that means we must strive to ensure that we leave no one offline.

Since being elected as ITU's Director of Development, I've focused on connecting the billions who remain unconnected, on broadening partnerships to accelerate digital transformation, and on leading efforts to advance education and digital skills.

As the UN agency for digital technologies, ITU has long advocated for the critical role of ICTs as a driver of socioeconomic growth and prosperity. Way back in the early 1980s, we commissioned the first ever independent study on the impact of access to basic telecommunication services on a country's national development. That groundbreaking report by the Maitland Commission, which was called "The Missing Link," offered clear evidence that access to communication technology is absolutely critical to every country's development prospects.

It's true that our message has taken too long to get through to the broader UN system of which we're a part of. But I can assure you that under the leadership of Secretary-General António

Guterres, the vital importance of digital technologies is now not just recognized, but very actively embraced by the entire UN family.

As we all now strive to put in place the right conditions for the growth and deployment of network and services, I'd like to share some thoughts on the immense possibilities for global development that lie untapped.

Powerful new technologies like 5G hold enormous promise for overcoming so many of the longstanding barriers that have blocked significant progress in global development. They offer the chance to leverage data and information in new and creative ways, and to use the analytic power of telecommunications and computing to create knowledge, to inspire new solutions to old-age problems.

The speed, capacity and low latency will push forward the frontiers of next-generation digital transformation. And for people in poorer parts of the world, that digital transformation offers a bridge to a dramatically better and brighter future. That connectivity offers unprecedented potential in economies where mobile is, and will remain, the only viable online platform for many millions who live beyond the reach of copper and fiber. That includes most of the developing world.

And of course, let's not forget satellite connectivity which can efficiently and rapidly deploy in reaching more remote geographic areas. Low-cost RFID sensors, voice- and image-driven smartphone apps and innovative use of mapping data are already helping farmers in Africa anticipate climatic conditions, combat pests, optimize water management, and improve crop yields and the health of livestock.

Looking ahead, 5G-EmPOWER services have the potential to dramatically transform healthcare, access to education, employment opportunities, environmental management, gender equality, and much more.

All of these will be critical to helping us make up the progress loss during the COVID pandemic, which has thrown so many of the 17 sustainable development goals off track. ITU partnerships, like our Giga education initiative with UNICEF, and others, to bring broadband internet to every school on the planet, that's going to rely heavily on fast wireless technologies to deliver rich content to schoolchildren in underserved parts of the world.

Wireless broadband is also the foundation of our Smart Villages initiative. Co-created with the communities that they serve, Smart Village hubs are already bringing a host of meaningful online services to rural dwellers in remote parts of Niger and soon Pakistan, too.

Ladies and gentlemen, as with 3G and 4G, there's still much work to be done to create optimal conditions for 5G to thrive and to realize its full potential. Getting the regulatory frameworks right will be crucial to driving rollout and uptake. We need to prioritize the enabling regulatory environment that sustains strong deployment so that the benefits of cutting-edge connectivity can be leveraged by all and for all.

We need to recognize that new infrastructure deployment is going to be costly. And it's also going to be complex. And that's why we need to work together as a global community, to seek out creative new ways to collaborate so that we put in place the access and skills that create a level playing field where every individual, every company, every country can make the most of emerging digital opportunities.

That vision was the driving force behind the Partner2Connect pledging platform that we pioneered at he ITU's World Telecommunications Development Conference earlier this year in

Kigali, Rwanda. The first ever UN pledging platform focused on digital connectivity. And P2C has already raised 26 billion in pledges from over 220 entities that span governments, the private sector and civil society. In fact, NTIA pledged to provide technical and business expertise to developing countries in their deployment of broadband and 5G networks.

P2C recognizes that governments, manufacturers, operators, platform and service providers, UN agencies, NGOs and consumers all have a stake in making this work because the benefits truly will be unprecedented. And this requires the engagement of all stakeholders.

Ladies and gentlemen, digital really does have the power to create a better, fairer and more prosperous world. The key to our success lies in our willingness and our ability to come together, to share, to learn from each other, and to work collaboratively to address the challenges as a community, and to make the ITU excel as an institution that's hardwired for the future and open to innovation.

ITU is committed to working with our 193 member states, our over 800 private sector members, our UN sister agencies and the broader development community to ensure that no one anywhere is left behind.

Digital is the new normal. But for all of us to benefit fully, we need everyone to benefit equally.

Thank you.

APRIL McCLAIN-DELANEY: What an amazing message from Doreen, particularly as we look to the ITU Plenipotentiary starting a week from today in Romania. I love how she talks about creative new ways to collaborate.

But as we do it, we're starting to look towards the World Radio Conference to be held in Dubai in November of 2023. We are now going to start looking at the WRC-23 issues. So I'll give a little background. I'm going to ask our next panel to come up to discuss these WRC-23 issues.

The issue of spectrum is increasingly becoming more high profile, as we know, is evermore linked to connectivity in our world economy, and influencing allocations in global use is a key priority for country administrations. And global businesses and platforms are ever amping their ITU participation, particularly in the ITU-R, or radio communications sector.

You heard a little bit about it in Doreen's speech, but way of background, the ITU is a UN-affiliated agency with 193-member voting states and about 800-plus sector members, which include the private sector and other NGOs. The WRC convenes every four years to review and amend the documentation that governs the international use of spectrum, the Radio Regs.

While countries administer their own spectrum policies, as we discussed this morning in terms of a national strategy on spectrum, the Radio Regs we've discussed, to coordinate it's helpful for these policies to be internationally aligned as well so there is greater harmonization of administrations in a given band for a given service. That allows for greater global operability, roaming and harmonized equipment, but also to prevent interference between countries' services. The Regs also govern locations of orbital slots and the use of spectrum in space.

The need for global consensus drives a four-year prep cycle that gives working groups the space and the time to develop views, build coalitions, and finally come to an agreement on spectrum policies which incorporate both industry and government perspective. And I think we saw that in Secretary Raimondo's and Alan Davidson's and the Chairwoman's comments today, how important innovation and competitiveness is as we look at all of these issues.

Other issues from a preceding WRC often define or foreshadow the agenda items of the following WRC; specifically, WRC-19 [02:56:33] WRC-23 might study mobile broadband services, known as IMT, across many bands, between 3 gigahertz and 10 gigahertz. There is also a multitude of satellite services and satellite-heavy questions that arose at that point.

So against this background, I want to welcome a panel, which is very well-known to many of you in the international spectrum area, holding decades of experience and perspective to the wireless, satellite and other government use priorities.

There's a longer bio on many of them, as you well know, but I'm just going to give a little bit of a snippet on each.

To my immediate left is NASA's Glenn Feldhake. He is currently NASA's International Spectrum Program Manager. But in addition to years in the tech and satellite industry – and I've known about him for a long time and it was just a pleasure to meet him recently – he's been working in the ITU arena for 26 years, and WRC-23 will be his seventh rodeo; seven times.

Next to him is Ambassador Grace Koh, the former US Ambassador to WRC-19, where she led a 125-member delegation in negotiation of US spectrum and satellite policy. Previously, she served as Assistant to the President on Technology, Telecommunications and Cybersecurity. Before that, counseling the US Subcommittee on Communications and Technology. She is currently a Senior Vice President of Government Affairs and Head of Office at Nokia.

Jennifer Manner is a Senior VP of Regulatory at EchoStar Corporation and Hughes Network Systems, and is responsible for global spectrum management and new technologies. Previously, she's held senior positions at the Federal Communications Commission, and has published several books on spectrum management. She has held several key leadership roles in the ITU-R sector and in trade associations.

And last, but not least, is Patricia Paoletta, a partner with the law firm HWG LLP, where she focuses on telecom and tech policy. Her clients span mobile broadband, satellite, and all things telecom. She also represents the wireless trade association 5G Americas as related to mobile broadband proceedings. She's a former classmate of mine, also, from Georgetown Law Center. So go Hoya Lawya!

And on this note, I'm going to turn to my panel, starting with Glenn, and ask each of you an initial overview question as to what is the importance or significance of WRC-23? Maybe go into, has COVID disrupted the normal for your cycle? Maybe so. And what is at stake in terms of how the agenda items will be decided next year. So maybe Glenn, you can start, and then we can go down the line.

GLENN FELDHAKE: Thank you, April. Good afternoon to everybody. Yeah, this has been a challenging cycle. Not a surprise to anybody, really, with COVID and trying to do things remotely. Next week, we're going to have an ITU Plenipotentiary Conference, which is sort of a treaty level conference above a WRC. And we're going to be looking at a lot of different aspects.

Several years ago, we had a plenipot and we started talking about remote participation. And at the time the subject was brought in of, how can we help developing nations that don't have the resources to send all sorts of people to Geneva all these times, months and months over years, to help them be able to participate, or at least know what's going on and it's not happening in a bubble. When we did that, we never thought, well, maybe six, eight, ten years from now there's going to be some global pandemic and the entire thing is going to be shut down. So it's definitely created a new normal for us.

I think we're doing pretty well. As best as we can. And we're back to in-person meetings with remote participation, but it's going to be a new normal, there's just no question about that. And there are some other factors contributing there.

From a NASA perspective, this has actually been one of the more science-friendly agendas that we have. We're looking at a number of agenda items which are the specific items on each WRC. They don't reopen the 2400 pages of the treaty and start with a blank sheet of paper every years; they have things called agenda items which are the topics. So there are a number of things that the science community is looking at. So there's a lot on the table for us that we're working on. Looking forward to it a lot.

I think with the COVID issues, at this point we're not as far along as where I would normally think we would be if we were back in the old-normal times, but we're definitely making progress and we're going to be working a lot of issues. We're working issues, not only science issues but issues that I'm sure when we hear the next keynote address after the panel from Badri Younes and also from the last panel of the day with RJ Balanga, we'll be talking a bit more about how NASA's been working with private industry to look at space-to-space communications. That's an important topic. NASA's trying to buy services from commercial satellite providers, but there are some regulatory hiccups that we have to get ironed out.

So it's a good agenda for us. The progress has been a little bit slow, not necessarily because of the issues being so contentious, but there's just been logistical points we've had to work through.

APRIL McCLAIN-DELANEY: Ambassador, having led the WRC-19 and morphing into WRC-23 over the past four years, how do you see this is of significance? And what are you focusing on?

GRACE KOH: I think the normal questions pop up – how do you get spectrum; the various industries will fight over where they can draw the lines when it comes to coexistence, et cetera. But I think, as a global backdrop, what's kind of interesting is the overhang of the pandemic and how the pandemic has accelerated, I think, the need for telecommunications, and, additionally, I think the need to digitalize a lot of industry.

So we're at a point where, notwithstanding what Doreen Bogdan-Martin just said about the millions of unconnected people, we're at a point where we're actually connecting more things than people, and we are starting to connect more industries to try to reap the benefits of what I think digitalization can bring – smoothing out everything from agriculture, to sipping logistics, to collaboration in the sciences. I think that those are the kinds of places that we're going.

And I think that WRC-23 is going to be placed at a very nice point for us to be thinking about that, particularly on the agenda for 27. And certainly, I think that'll overhang the entire WRC-23. And that should be pretty interesting.

So when I hear that spectrum is the lifeblood of communications, as Senator Wicker said today, I think, well, um, nuh-uh [laughter] – spectrum is the lifeblood of the next economy. It is that fundamental. And figuring out how to maintain US leadership in this effort is going to be critically important, including figuring out ways to collaborate when we still have a pandemic going on and still try to move those agenda items forward. That's been sort of on my mind.

APRIL McCLAIN-DELANEY: Jennifer, you come from a real satellite background, as well as a larger background. Tell me what you think.

JENNIFER MANNER: I'm just back from Geneva as of Friday for a working party 4B with some of Glenn's colleagues and some of my other panelists' colleagues. I think we're at a critical time. And, interesting take with Glenn, we're not as far as we should be, but we don't have a

choice. We have a conference preparatory meeting coming up in the spring, which means we're at our limit meetings for finalizing conference preparatory text. And for those of you who don't know, the CPM text will be developed at our next pre-conference meeting. And that will really set the framework for description of the different ways that agenda items can be met. So there'll be a variety of different methods.

I have to say, and I have the honor of chairing one of the subworking groups, is it's fantastic being back in person. If we were still remote – I see Tricia shaking her head – I think we would never have gotten to the conference preparatory text. I think having the last two session meetings in person has been incredible.

In terms of this conference, I think there's a huge amount of things at stake, and some of them are things that I think really became more important than we thought. And I'll focus on the satellite issues. And I know one that NASA shares with me is the importance of intersatellite links and making spectrum available there; that's an important issue to watch.

Another critical issue Grace and Glenn both touched on, sharing, and I know Tricia, too – besides looking at the IMT issues and important issues, like sharing with our lands and satellite and other services and making sure existing services are protected, there's an item under what we call Agenda Item 7 on Section 1503, and this is really how NGSOs and GSOs share spectrum or operate together. And that's an area that I think is going to spend a lot of time.

But I did want to touch on three areas that I think most people aren't focused on. One is, there's an agenda item that was put on at the very tail end – Grace will remember, the Ambassador will remember this from the UAE – and that is to start to look at all of the fixed service bands for IMT. And no one really knows where that's going, and I think that will get developed and turned into some sort of a future agenda item for the 27 conference.

But two other issues which aren't necessarily on the agenda but I think will come up: one involves operating on a noninterference basis. And what we're seeing in the satellite industry– and actually on Friday, the FCC authorized one company, Lynk, to go ahead and do this, which is the use of terrestrial spectrum on satellite systems. And whether that can really be operate– what will it mean when they're operating on a noninterference basis because they're operating in spectrum that's now allocated for mobile satellite service. I think there's other services that we're also seeing that were applications and uses that are operating on a noninterference basis. I'd be surprised if that doesn't get the attention of the WRC.

And the other one, which not that this conference, but I think will certainly hit the next conference, which is the issue of aggregate interference. And that's both terrestrial and space. You can't have billions and millions and trillions of devices on the ground and hundreds and thousands of satellites in space without some sort of aggregate impact. And I think that will come to pass.

So I'm kind of excited to see how these issues are addressed at the conference and also at the next few years. I think they're important for industry and for the government. Thank you.

APRIL McCLAIN-DELANEY: That was very insightful, having just come back from Geneva. Patricia?

PATRICIA PAOLETTA: Thanks, I'm delighted to be here. Thank you for inviting me and including me on the panel. I'll start at a very high level and I'll key off of some of Jennifer's points. Obviously, with the events of earlier this year, it's very important that the world can come together. The ITU, the International Telecommunications Union, is a body of the United Nations. It's very important that the world can come together at the United Nations and discuss and solve some of these thorny issues, issues some of the– well, all the panelists have addressed, but particularly Jennifer was mentioning the use of MSS spectrum for terrestrial real 5G and

partnering together on that. You also mentioned RLANs, which is ITspeak for radio local area networks, what we would call wifi in the United States. And the use of IMT, again, mobile broadband technologies. Primarily those that come out of 3GPP, but for fixed wireless.

You're seeing, and it's no surprise to those of us who work in Washington in telecom, technologies are competing, they're getting to each others' markets, it's evolving, it's innovating. But in the ITU, we have kind of strict, decades-old definitions. And of course these things are converging and it's confusing, what terminology we use. So it's important that the world come together and kind of sort these issues out so we have the goal of harmonized spectrum band. So you have the economies and scale and roaming, and all those good things that come from that.

But now to dig in to what matters for my clients. On the RLAN issue, on radio communications local area networks, or wifi, the ITU generally does not get into licensing frameworks; they leave that to the countries, the sovereign countries, but generally that's what folks think of, RLANs being wifi. And that is one of the bands that is in the mid-band spectrum, item agenda Item 1.2, looking at mid-band spectrum for broadband.

The study item that was pushed forward, by the Chinese, basically, Huawei, is to study the use of the upper 6-gigahertz band; in only region one, technically. But you might recall, a little bit after the last WRC, the US moved forward with allocating the whole 6-gigahertz band, 1200 megahertz, from 59.25 to 71.25, for unlicensees, what the US called.

The beauty of that, it's a lot of spectrum, but the beauty of that is, the incumbents can stay put. There's a lot of important fixed use in that band for fixed microwave links used by the cellular industry for backhaul, like public safety. There's satellite in that band. But the United States could make that available for unlicensed devices, and it didn't specify wifi. Again, that's the beauty of the US system; that can be also unlicensed technologies with different flavors.

We made that available, and soon after a lot of other countries followed suit. But then advocates of IMT in that band, particularly China and Huawei, started telling folks "don't move forward, don't prejudice yourself, let's wait." And that is an important issue, really, from the whole US perspective because that would be an innovation band.

We heard from Harold's panel, and others, that we need to keep innovating. With that full 1200 megahertz, you can move from wifi-6, wifi-6E, meaning the 6-gigahertz band, into wifi-7, which is optimized with those really big channels of 320 megahertz. The wifi industry, it's global, but the US really does lead in terms of intellectual property and economic output.

So it will be crucial for the US to ensure that IMT identification of that band is very limited, certainly does not creep out beyond region one, which is Europe and the Middle East and Africa. Ideally, it will stay with those proponents who are largely Africans and Huawei in terms of identification. But that is critical; we will have the future.

6G, Huawei is looking at, reports show, are looking at the 6-gigahertz band for 6G. So we don't want to have the same saga we had in 5G – win the race to 5G and then go around trying to convince our European allies and the Five Eyes that it's not good to rely on Huawei for their 5G. We need to be resolute and make sure that that band, 6 gigahertz, is our innovation band and the world's innovation band and will not be controlled basically by the Huawei interests.

I'll leave it there; we can drill in on other issues.

APRIL McCLAIN-DELANEY: There's a lot to unpack in all those different issues. We kind of did the full range, which I what I wanted, but I want to bring it back to this morning when the Secretary kicked it off about US leadership and competitiveness and being a global thought leader, which I think is really important. We had comments about rethinking what the future

looks like and how spectrum is limited and we have to look at innovation and coordination and have longer terms to study it, and sharing.

So I think those are all amazing concepts to interweave in all of these, but I do want to go into WRC-19, about Agenda Item 1.2, which includes proposals to our 5G access in multiple new frequency bands between 3 gigahertz and 10.5. So there's two parts – how do we balance– there's our national strategy on spectrum and how we're coordinating here, and then this international, global way of looking at it. How do we balance the needs of mid-band spectrum for 5G with the needs of – I think we talked about it a little bit – federal uses, including air traffic control or weather or climate or things of national security and just public interest. And to what extent – this is what's really interesting to me – the enforceability and how different administrations are likely to share this need to balance commercial and government access in this range, and to also play the rules.

I might start with you again, Glenn.

GLENN FELDHAKE: Okay, sure. It is an interesting question, of how do you balance. One of the things that I always come back to is, all of these uses of spectrum really are interdependent. They're not different technologies that operate in a bubble. I was thinking about this this morning. I work in Ohio, actually. I flew in last night. The first thing I did, pulled up my 5G phone because I wanted to know what the weather report was, and could I walk over here or was I going to have to Uber it. So I pulled out my phone. I don't know if I was doing data on cellular or wifi, I really wasn't thinking about it.

Called up my weather app. The weather app gets its forecast based on data from satellites; the satellites have to get their data down to the ground. How do the satellites get their data in the first place? Well, they've got remote sensing on them where they're picking up molecular– basically body radiation coming from naturally occurring molecules. Which, by the way, we don't get to

regulate Mother Nature as to what frequencies Mother Nature decides. We can't say, change channels [laughter], or, we'll give you funding to change the molecules. It doesn't happen that way.

But it's completely different technologies, but I need all these technologies to work together in order for me to find out, am I going to get rained on today? And it can get much more dramatic than that. I'm worried about not getting rained on; people in Puerto Rico are trying to figure out, where's the hurricane going to hit? It's the same thing.

And so, the first thing to figure out how we balance is we have to figure out how the technologies fit together.

And to the second part of your question on different countries, this is one– because I do a lot of work in CITEL, and CITEL's basically where all the nations from North, South and Central America get together prior to WRCs and get together and compare notes on where we are in developing proposals for the WRC agenda items. And CITEL, I view it as a fun challenge because if you look at the Western European countries, they're all socioeconomically about the same and their priorities are going to be– they'll be aligned somewhat, or more aligned. You start talking about major developed economies like the United States and Canada, and then you look at other economies in Central America, South America, they all have spectrum dependencies, but their priorities for those spectrum dependencies and what they want to accomplish may be really different. And we have to get together to develop regional proposals where we're trying to hit that balance with everybody.

It's a fun challenge. There's a lot of interesting conversations about how to get– especially when you're in space, like NASA is, we don't necessarily– we're just not thinking about the same things as other countries. Our priorities are all different. So hitting that balance is just about right.

The other thing I like to point out, going back to the issue of how all the technologies, the spectrum dependencies are interconnected, this is something I have to hammer on over and over within my management. My management knows, NASA management knows spectrum is important. We've got this next great mission going into space – do we have the spectrum for it? They know that.

And I have to keep saying, Yeah, that's important, but if you look at all of NASA's frequency assignments that we get from NTIA, 70% of them, neither the transmitter nor the receiver is in space. It's, security guards need walkie-talkies. It's, we have a new auditorium, they need wireless microphones. It's, there's a building on this side of the campus that's doing experiments with a point-to-point link to another building that's got the data collection computers. We're not completely like, well, all we do is talk to satellites and we don't ever use a radio for anything else. It's not.

It's a fun problem, but it is something, it's a challenge to try to meet all these different considerations. And I don't know that in other countries there's going to be– where it's federal/non-federal. That's kind of a uniquely US problem.

Definitely the priorities, we've got a lot of– there's plenty of countries in this world. They just want to know, how can they get internet into schools. Just a completely different viewpoint because they're coming at the– their priorities, their requirements are just different.

So there's a lot of talking that has to go on to understand how we reach that balance. But the biggest issue from my perspective is, don't say, well, this technology is for this and will only ever be used by anybody for one thing, and this technology is only ever to be used by certain people for one thing, and try to draw this bubbles. It's all independent. It's not independent.

APRIL McCLAIN-DELANEY: Ambassador, if we rethink what the future looks like, I think you said we're connecting as much things and devices in the Internet of Things as people, how do you think different administrations are looking at this balance? We have different priorities, but in a global basis, how do we deal with this as we're trying to have harmonization and look at interference? I love the aggregate interference because that's kind of a really interesting thought.

GRACE KOH: I think it's a tough question. I would say, particularly going into this– 1.2 is incredibly important to Nokia, its customers. Finding the right balance, the right set of parameters to allow the IMT identification of those bands is critical.

But I think generally speaking, flexibility in the way we do this allocation is going to be key. Allowing for the most flexible use and expanding the possibility of uses for the spectrum is, I think, key to this particular question on 1.2, and then also– Agenda Item 1.2, rather. But it's also going to be key to, I think, a national spectrum strategy going forward.

I definitely want to point you in the direction of the Aspen Institute Roundtable on Spectrum report, which offers a lot of, I think, unique ideas on how to make the most– unique recommendations of how to do more with what we have. Among other things, it certainly asks NTIA to set out a ten-year roadmap to sort of signal where we're trying to go, to show a recognition and reflect what's happening to spectrum, what changes are happening, the shift from people connectivity to thing connectivity, the need to increase sharing options and perhaps bidirectional sharing, the possibility of overlay licenses for incumbent users, to be able to make use of spectrum that you can use spectrum around the margins of incumbent users.

But all of that requires extensive study, extensive testing and a willingness to actually come together and have those conversations. And that starts certainly with the United States. And the hope is to be able to bring those kinds of studies because the US, let's face it, is probably going to be more cutting edge than anyone else, given the flourishing of a lot of different tech

industries here than many of our CITEL brethren. And to take that information and to be able to share it with others so that that can be, I think, we can have a meeting of different sovereign nations to come to an agreement on how we want to move forward with this.

As for enforceability, I just wanted to point out I think the biggest barrier to– the biggest stick, really, is the potential for complete chaos when you're not abiding by what the regulations say. Nobody wins when people step out of line, step away from the rules. And I think that is the main, I think, behavior-shaper for people using spectrum.

That being said, I think– so I think that ends up being the biggest stick. And that is ultimately why I think people fight tooth and nail at the WRCs and the study groups, because they want to set the rules in the best possible light for their particular service.

APRIL McCLAIN-DELANEY: It's interesting, these working groups, it's consensus-based and that's why it takes so long to get through it and to agree. And sometimes things are pushed off for another WRC or there's no change. But it seems like this laborious process has historically worked. And you always kind of think, what is going to happen if you're not respectful of those and how we deal with it.

So Jennifer, jumping on the Ambassador's comments, but also we had this whole discussion about transparency and sharing information. How much do you feel like some of these administrations in this dialogue are sharing information? I think someone said today "go fish," and I love that analogy of, like, okay, go fish, what do you think. But if we lay down our cards, how many of these administrations are truly coming and laying down their cards? It seems that we won't be able to really balance appropriately if we can't figure out what's going on behind some of the incentives.

JENNIFER MANNER: It's a complicated answer, but I'd start with the ITU is contribution-based. So there have to be people who come in or countries– the difference between the WRC and the study groups is, it's not really true, but essentially that the small-m members – those are folks who are companies and other institutions and so forth – come and at the WRC they don't have a vote, but at the study groups, they are at least considered pretty strongly same as countries. So of course, a number of companies and others serve on country delegations.

But the big thing is, you have to have inputs and you have to have the technical studies to get the work done. And at the end of the day, when you look at who puts in the studies, it does tend to be the larger countries like the United States, some of the European, some of the larger countries around the world, the folks who have more of an interest. And of course the companies put in a lot of studies.

So you work from the information you have. So you can't just make up– I just came back from chairing an agenda that has nothing to do with IMT, thankfully [laughter], but has to do with additional spectrum for satellite. But in that case there was kind of a similarity.

Just so folks know, IMT is not a spectrum allocation. It is a footnote to the table of allocations that provides guidance to countries and where they want to put in; in case, IMT 2025 5G. But we try to avoid generally at the ITU making spectrum available for applications. My Agenda Item 1.18 was focused on making spectrum available for low-power mobile satellite service, narrowband service with very specific characteristics, including very low-power operations that would only transmit for four seconds every 15 minutes.

And we did get some studies, but our problem was somewhat different in that we didn't have a clear agenda item from – not your fault [laughter] – from WRC-19. It was a final agreement and the resolution that came out was very unclear because it was a compromise in the last 48 hours of

the conference. And so, we actually only had studies introduced at my last correspondence group in the summer, and then we didn't have the time to do the studies.

So I would say it's not so much transparency; it's having the studies and then having the resources in-country to actually analyze those studies. So we do tend to rely on the larger, more technologically advanced countries, especially at IMT. And I think you'll see some real players there.

I did want to touch on the enforcement because IMT is an area where actually Europe tried to enforce an IMT identification against the US many years ago. Scott Blake Harris probably remembers this. It was in the PCS bands. We chose not to make the bands available for IMT at that time, but for PCS. And Europe actually sent a letter to our State Department accusing us of violating the IT Treaty. And of course, that isn't even an allocation; we certainly weren't causing interference to Europe.

But it goes to what Grace says. I think the ITU works because none of us want interference, and it really works from political pressure. And it is an interest of the different countries to work to find a solution. It is one of those places where very rarely does everyone go home happy. Usually there's a couple of groups who are less than happy.

So I don't know if that answered your question, April.

APRIL McCLAIN-DELANEY: It did. There's a song, "you can't always get what you want." I think that's what you're talking about. I was even thinking about, we were talking about playing that as you guys came out. [laughter] But hopefully we'll get what we need.

So Tricia, thoughts on that?

PATRICIA PAOLETTA: Sure. So your question, as I was listening to it, was, how do we balance federal needs, particularly in that mid-band spectrum. This Agenda Item 1.2 addresses basically three ranges – 3 gigahertz; 6 gigahertz, which I addressed; and no change, which is the current use position. Means yes, no change to that international table of allocations. Those of you who practice before the FCC know parts of the US Regs is the domestic table and the international. And this treaty conference is about changing –or maybe not, no change – to that international table. And for the US, there's already a mobile allocation; you don't need an identification for a particular application, so it's no change.

But the other band is 10 gigahertz, and that's a NATO band. You can imagine the Europeans maybe this year don't really want much of a change in that allocation to identify it for IMT, but we'll see what they produce.

But the US, because we have federal systems and have a very important federal system, as we heard from the CIO from DoD and Alan Davidson, very important systems, radar and others, in 3 gigahertz, we've done the hard work. We did the hard work in looking at CBRS where we have a tiered approach. We have some basically generally authorized license-light. We have licensed exclusive spectrum. And that is, exclusively licensed spectrum is the golden standard for the mobile industry so they can protect against interference, they can plan it, more security; it's very important. We always balance in the US unlicensed and licensed.

And then, but we've also done the hard work in C-band where it was very painful and difficult, but we repurposed some of that satellite spectrum and had the auction of the C-band spectrum for over $90 billion. We've done that hard work in the United States, figuring out how to share the band, how to repurpose.

And of course we're looking further down the line, including into the band that 3GPP has identified as the core band globally for 5G; we heard Chairwoman Rosenworcel talk about 3 gigahertz being the key band for 5G globally.

So we've done the hard work. Hopefully we can convince others to look at the work we've done in the United States. And we've got studies on that as well to kind of follow it. But the rest of the world, they are not quite as comfortable as US is with sharing. But we've done and hopefully we can lead the way.

APRIL McCLAIN-DELANEY: As a follow-up on that, and I think it's really great, because you've done a lot of work with CITEL, it seems like. I know many of you have, but I know, Patricia, you in particular. And looking at, if we've done the hard work in the United States, but then when we look at in the ITU, there are regions of the world. And US is in the Americas region of CITEL. Are there agenda items that you're talking about that specifically the US will likely have difficulty developing proposals for getting CITEL or interAmerican proposals for? Are we likely to have difficulty getting through or getting CITEL interAmerican proposals? Is there a sense of urgency in completing these proposals for the WRC? It seems like it takes a little bit of time to work with our international partners, within our region and then globally.

PATRICIA PAOLETTA: Not that I want to duck your question, but– we are behind the curve. So we only have a few, a handful of proposals where we've told our neighbors in the Caribbean and the Americas that this is what we want this to be. And we don't know yet where all the difficulties are going to lie. I'd like to think the mid-band one will be super easy to resolve. I think we're going to have some bumps in some of those bands. Some of the other panelists can talk maybe about satellite or the science, but we haven't yet really tested the waters because we are so far behind.

Historically, the US has had a really great track record at CITEL with other countries following us because we have deep bench and we have the industry and we have a great dialogue between the FCC and NTIA, and great scientists in Boulder and elsewhere. So they tend to listen to us, but obviously, as Glenn mentioned, they have their own interests, too, and their own priorities.

So we don't yet know, but we're hopeful.

APRIL McCLAIN-DELANEY: So Glenn and Jennifer, in the satellite arena, how are you looking at this in terms of the sense of urgency, and also within the Americas, how you're looking at all of these different coordinating proposals and also within the region.

JENNIFER MANNER: I would actually say we're still early in CITEL. So CITEL is, I'm looking at Glenn, is a more relaxed region than perhaps other regions. [laughter] And that's a good thing, I think, in a lot of ways because it allows us to go talk to people. If you go to a CITEL meeting, a lot of the work happens outside of the meetings. We have very good relations, the US government in particular has great relations with our neighbors to the south and north and in the Caribbean. So a lot of this is done offline.

Our next meeting starts on Halloween. But that's the last meeting we have before the conference preparatory meeting. We really focus towards the meetings right before we go to WRC, which we call the limit meeting. And that's where we really come together, I think, as a region. And there's a whole bunch of listening and understanding and balancing needs.

So I think we will get there. We always have gotten there. I think it's a strength, it's something that we're very incented on doing. And we're going to use the next, I think we have three meetings before the conference. So we still have time. So I'm very optimistic.

The other issue we also spend at the limits meeting is, what are our future agenda items going to be. And that sometimes is harder than coming to agreement on the actual proposals because we spend so much time talking about them.

But I'm not worried about time, April. I think we still have sufficient time I think there probably more than we do at the ITU in a lot of ways because it's just a less formal body.

APRIL McCLAIN-DELANEY: At the plenipot for this year, they had to collapse a lot of meetings that had not happened virtually into one year. And so there was a great deal of travel in anticipation of the plenipot this year.

So, Glenn?

GLENN FELDHAKE: Largely agree with what Jennifer said. When you talk strictly from a science perspective, many countries CITEL don't have space programs. So it does take a little bit more time sometimes to work an issue. Pull people aside, not have people on a microphone sitting behind a flag and going, Thank you, Mr. Chairman or Madam Chairman, but to actually have coffee and just talk it out and say, Actually, this is climate monitoring and disaster relief and things you do care about which we make publicly– but you have to, there's always a process of education. it just takes a little bit more time on some of the science issues. So from that perspective, it would be–

APRIL McCLAIN-DELANEY: Could you illuminate a little bit, because you said a couple times it's a really scientific agenda. Tell the audience, why is it so scientific and why is it different from 19 or previous WRCs?

GLENN FELDHAKE: Okay, I usually after each WRC I categorize agenda items into, here's the stuff where NASA wants to get something done, or the science community, because we work

very much with the National Science Foundation and work closely with NOAA where we want to get something done. Other agenda items, other folks have their own requirements, which we need to look at see, will we be potentially impacted? Or are there ways we can make it all work out with proper terms and conditions?

At WRC-19, I had something like seven, no, eight– it flipped. I had eight agenda items where scientific interests were potentially at risk; four where we were trying to get something accomplished to benefit the science community beyond make sure nothing bad happens. For WRC-23, it's the other way around; it's eight where we have. So for example, I'll just pull one at random, Agenda Item 1.12. We're looking at getting a secondary allocation to do basically space-based ground-penetrating radars. These ground-penetrating radars could operate over the poles and see how much glacier you go through before you hit bedrock.

So you can measure the thinning of the ice sheets. Or, you could go over desert areas and see how far down is the water table to see if the water tables are going up or down. But we need an allocation because the physics of making radio waves penetrate surfaces and come back up is kind of tricky. So again, it's one of those Mother Nature issues.

This is not something that people in a lot of developing nations are– I mean, they're very aware of climate change and the impacts on some of these things, but it's something that on its surface, if you just hit them with the physics of, well, at 45 megahertz, the soil permittivity is– no.

So it just takes a little bit more time of talking about it. And they're all totally smart people; they're probably smarter than me, which isn't setting the bar real high. But you do have to talk through it a little bit to try to get along.

I do agree, as well, I think one area where we're going to have some– well, another area where we may have some difficulty is we have an Agenda Item 1.17, which I touched on with NASA

buying commercial services from commercial satellite providers to relay our data back. That one's just complicated. It's not a contentious issue; it's just when you look at all the bands that are being considered and all the other incumbent services, and you could share this way, you can share that way, there's just so many studies. The workload. And as we said, with COVID, trying to get to the end of these studies and be able to reach a conclusion, it's a push.

But I agree with Jennifer. From a proposal stage in CITEL, I don't think we're out of time. I think we still have work to do; we definitely have work to do. But I'm not panicking yet.

And then finally, the last one that was always an issue is coming up with those agenda items for WRC-27 and coming up with, what's that agenda going to look like? That one's always a challenge. There a lot of negotiation that goes into, what's the next agenda going to look like.

APRIL McCLAIN-DELANEY: And that's what I was going to turn to the Ambassador about. This will be your second. There are 13 preliminary agenda items already in WRC-27. And I was actually reading through them and I'm like, wow. Including 6G, which is likely to be added. And some of the WRC-23 items will roll over, particularly it seems like if we're not able to get through a lot of the technical or coordination or other types of events, or just scheduling of differences of opinions.

How do we manage to limit that WRC-27 agenda to something manageable? And how important will it be to ensure they precisely write resolutions that accompany the WRC-27 agenda items? It would be great if you would do the sausage-making. I've been to the ITU, but I think the sausage-making, it would be really interesting. And I know, Glenn, since this is his seventh rodeo, he's seen it, too. All of you. But giving a little bit of the birds-eye view would be helpful.

GRACE KOH: The process for the last WRC-19 for the development of the agenda of WRC-23, as many of you remember and there are the scars from, was not ideal. I think really, it starts

with the US delegation in determining what is a priority for the US and certainly figuring out where we want to spend our time, and then working with CITEL.

It's going to be important who the next WRC Ambassador will be, right, because that person will be working to promote the US positions for all of the agenda items, which is one of the things that will help us get to consensus at CITEL. But also working to promote consensus on what the next set of priorities ought to be.

I don't think that the US would have had any say on the 1.2 agenda item on the IMT Agenda Item if I hadn't started having calls with Brazil, Canada and Uruguay, very much on the downlow, just trying to figure out where we could start to come to consensus on this. Because there were no bands that anyone really wanted to touch, and everybody was pretty much done with wanting to allocate any bands for 5G. If you want to call WRC-19 anything, you can call it the millimeter wave and the NGSO megaconstellation WRC.

But it starts with sort of a side conversation to get people comfortable with the idea. That's what we all missed by not having in-person meetings, the ability to walk off and say, Hey, I heard what you said; let's pull out pencil and paper and actually work out the math here. I actually saw Alex, now at Piper, do that over one of Agenda Item 7 items. But it's that kind of thing. I'm sure Scott's pulled out paper and pencil and started working out the equations, sent people screaming out of the room. But that's the kind of thing you have to do to start to get to consensus.

I worry about 6G is going to be on the table, mainly because I think it's going to be the new kid on the block; it's going to be very flashy and people will want to– governments always want to do something about what's new and what's flashy. I think certainly we have to make preparations for that. But we're still identifying bands in the standard place, in the proto standard space. We're not even at the 3GPP space.

So I think maybe some preliminary items on studying and identifying bands will happen. But more importantly, I think we really need to start thinking about how it is that we do better coexistence and how we start to cordon off this mess that has become the way we measure coexistence and interference. And try to at least start to align around assumptions that we're going to take when we're actually working on known technologies.

APRIL McCLAIN-DELANEY: I love that. Jennifer, coexistence?

JENNIFER MANNER: [05:43:56] [laughter]

APRIL McCLAIN-DELANEY: How many WRCs have you been involved with? How many rodeos?

JENNIFER MANNER: I have to count. I started when I was two. I was a mere child.

APRIL McCLAIN-DELANEY: So tell me, what do you think about the 13 preliminary agenda proposals? What is your take on moving it thru and making it manageable for 27? But also this collaborative process that hopefully we'll have to facilitate some of this dialogue.

JENNIFER MANNER: I have to say the future agenda items is my favorite part of the WRC and one of the things I actually spend a fair amount of time on because I actually think it's the most important part. The work's been done on the other stuff. You're going to have a decision and hopefully it'll be a reasonable decision. But what you're going to put on the WRC-27 agenda is fascinating. I've had the opportunity over the past few WRCs to chair either satellite or space appropriations for the WRC. And the amount of ideas is just unbelievable.

But what I also think happens is there is a certain rationality – as much as I hate to use that term with the ITU because most people don't really see – that people do come together and they really do try to put forward their priorities when you're in smaller groups.

The interesting thing about the WRC is, you start in this huge room with whatever, 3000 people, over 3000, and you work down. And then you break into these very small groups. And really, I think the future agenda items really get vetted in these smaller groups when you're putting together what you have and it starts to make sense. The cream rises to the top; what's the most important.

So I think there is a tension, always, how many agenda items we're going to have. And that really ends up at the higher levels. But usually you end with a few that are easy to choose from. And then it's a political decision. I'm looking at Grace, because she would have made those decisions. But it's not like the Ambassador and the other leaders don't end up with 60 agenda items; they end up with something more reasonable. And hopefully through negotiations and understanding what the priorities for the countries are, we end up with a reasonable list.

So I actually think it makes more sense than perhaps you would think it does. And I do think that a number of the agenda items that are on that agenda won't make it, or will be changed because of work that was done during this conference that we say, well, maybe we should look at it a little bit differently.

APRIL McCLAIN-DELANEY: So Patricia, we talk about global competitiveness and innovation and freeing up spectrum and all these issues we've been talking about all day, but also how we work collaboratively to look at these agenda items with industry. There's 800 sector members that are part of this. There's 193 member states, but 800 sector members. How does that all work together when you're at one of these WRCs? How do you get that information and how

do you share it in a way as you're working through proposals? How does the US delegation jell in terms of furthering a unified front on our priorities?

PATRICIA PAOLETTA: I will say the WRC delegations I've been a member have, I think there has been good adherence to the rules, of not sharing information outside the delegation. As Jennifer mentioned, it's about 3000 people running around, a lot of buzz going on. But discussions within the delegation are expected to stay within the delegation. It could be challenging because, as you said, April, the sector members can show up as companies or associations or academic institutions, as paid attendees. And they're there, and they can speak on the mic in most cases. But even if you have clients who are those members, you are not to share information within the US delegation with those members.

So it can be challenging. But I've been impressed with the US delegation's discipline and adhering to the rules. Because it's a messy, monthlong conference. And we need order.

 I come from the House back in the day, as opposed to the Senate. In the House, we had rules. There's more people, you have to follow those rules.

APRIL McCLAIN-DELANEY: The people's House.

PATRICIA PAOLETTA: The people's House, the US House of Representatives. You're familiar with that House.

APRIL McCLAIN-DELANEY: I am familiar with that House.

PATRICIA PAOLETTA: The US has been very successful, really, at the WRC over the years because, I think, of the discipline. And the diversity of our delegation; we have traditionally the largest delegations to WRCs until China surpassed us, I think, last year, or last cycle.

So I think it really does take great leadership of the WRC US delegation, which we've had. And then commitment to playing by the rules by US delegates.

APRIL McCLAIN-DELANEY: I'm going to ask one more question of you all that kind of rises up that I've seen in my work with the plenipot. But as we go through, I think we end, is it 1:50 that we're ending? 1:55. Time check, time check. We really haven't had any questions, and I think it's great to have a couple of questions from the audience, a couple, two or three brief questions at the end.

In the areas of wireless standards, we're seeing some overlap from other ITU sectors and to the ITU-R area of expertise in a larger sense. Countries are seeking to expand the ITU's portfolio into areas such as internet regulation, privacy standards. How do we ensure that the ITU retains the right focus on important spectrum issues of the future? And I say this having been in mini-bilats with garnishing[sic] votes for Doreen Bogdan-Martin. And sometimes it's the only forum that a lot of development countries can come to or afford to come to. And so, when they see cyber or they see things that are bad actors on the internet, the only place they know to go is the ITU. But the ITU is for technical matters and matters that deal with more orbital slots, technical matters.

So how do we both figure out how to ensure it has its right focus, but that there's dialogue? I'm going to start with Jennifer.

JENNIFER MANNER: Thank you, April, for the question. There's actually an issue that's likely to come up at Plenipotentiary that's near and dear to my heart, which is space sustainability and whether the ITU should get involved in that. I think just looking at that from my personal perspective, there are certain roles the ITU does have in terms of orbit, but generally they don't

the expertise on things like orbital debris, nor do they have the funding to do that. And I think that's the concern.

Putting aside politics and whether from a US perspective we think the ITU should be involved in certain areas, there's just certain practicalities. And the ITU is under incredible budget constraints beyond probably– I was talking to people while I was there and really, really surprisingly not being able to meet their budget, even when we're remote.

So I think the way we can do it is through the other sectors, especially the D-Sector, which I think Doreen has done a terrific job at, is having regulator-to-regulator discussions, handling it through trainings and other things where you're not getting involved in the policy, but you're giving regulators the tools to address things. I think that's critically important.

Using organizations like USTTI has always been excellent. Jean-Pierre is in the room and I'm going to embarrass him, but he's doing a bunch of trainings with foreign governments through Carnegie Mellon University and also the State Department, where you're giving regulators the chance to explore this, but you're not bringing it into the ITU and creating regulation.

I think things like that the US has always been good at supporting. And we should continue to do.

APRIL McCLAIN-DELANEY: Patricia?

PATRICIA PAOLETTA: Everything Jennifer said I agree with. Because of the economic importance of harmonized spectrum for the telecom industry, writ large, there's a lot of heat and light at the ITU-R. People have meetings there, they attend. And that's why you do see some of these other issues getting pushed into the R-AMBIT because people will have meetings, there will be discussions.

But it is important to keep the ITU focused on its mission and push back at those trends. Which I think the US has been good at doing.

APRIL McCLAIN-DELANEY: What about as we get into AI and standards and things that actually impact how we share spectrum? Or we start to get into other technical issues that intersect? Is there a way, Mr. NASA, Mr. Science? How do you define the line of where some of those technical standards intersect with radio spectrum and in the management of networks?

GLENN FELDHAKE: Well, I think the overall discussion here, there's two different topics that we're looking at. One is the requirements creep. Obviously, the ITU has to stay current with technology and as new technologies evolve, the ITU needs to know about them. But there have been, I know, a number of areas where the ITU has really gone, "you're hosting a meeting about what? And I can't get a meeting room because why?"

But there's also, I think to the more significant issue, is where we do see, as you brought up, WRC overlap. The ITU is in financial straits. It's not good. And the last thing we need to do is duplicate efforts. So it's a double issue that we have to worry about.

With respect to the requirements creep, I'm hoping we're going to have some of those discussions. We have this Plenipotentiary starting next week; it's going to be three weeks in Bucharest. And that one is a tough– I've got it right here my notes, that's a tough one. How do you draw the line if what's in scope or out of scope? The plenipot will define the scope of work of the I2T, I2D, the I2R. They're setting the budget for how much money from the countries' dues go into each sector of the ITU.

So I think there is a certain element of you can only give– and the US has always been very, very good about saying, let's focus on the core mandates of the ITU; that's just been a rallying cry for I don't know how many plenipotentiaries in a row. But it is a discussion.

But trying to figure out what is or is not in the core mandates of the ITU when– the Plenipotentiary is where you an redefine them if you want to. It gets tricky, especially when we're talking about new technologies that possibly haven't even been developed yet. We had, I remember in Plenipotentiary '02, we had discussion about what is the ITU's mandate as far as its legal jurisdiction over laser com? And that was an interesting conversation.

Now we're talking a lot about artificial intelligence. Artificial intelligence, on its own, it's so broad. No, that's clearly out. But if we start talking about using artificial intelligence to promote sharing, well, that's probably a debate that folks are going to want to have. It's not an easy one.

So I'm here to say I don't have the answer right off the top of my head; otherwise, I'd be more important than I am. [laughter]

APRIL McCLAIN-DELANEY: Very insightful. So Grace, bring us home.

GRACE KOH: Well, you are important, Glenn, and I'll tell you why. One of the things that's going to be critical in terms of trying to limit the ITU's scope creep is having more Americans at the ITU, having more like-minded allies at the ITU. Doreen Bogdan-Martin is a bit of a unicorn. I don't think any other US person could be elected to a major leadership point at the ITU, and she's poised to become the Secretary-General. But that shouldn't be the case. We should have other Americans there who are able to do that kind of work, who are able to reach other countries and be able to speak to them in their language, but also present the values that I think are critical to a flourishing liberal technology order.

And so, people like Sandra Clark and Scott Kotler and John Alden and Dr. Vanderley, they're all important. But we need more of them and I don't know where we're going to grow them all.

APRIL McCLAIN-DELANEY: Interestingly enough, I heard something like 60-65-plus of the people who attend these meetings are over 50. So we have to grow more technical and skills at the ITU American delegation.

GRACE KOH: Absolutely. And you're important, Glenn, too.

GLENN FELDHAKE: Thank you. Just to add on to what Grace said, at WRC-19, NASA had seven delegates. Between the three of us, we had something like 26 WRCs between us. The other four, we had one guy who'd been to one. And spectrum management, this is not any– I always say, we have the 3000 people in a room representing 160 countries with different socioeconomic development, societies, technologies, religions, social norms, all of this. The one thing that you can say that when you sit down in that plenary with the 2999 other people is, nobody in that room when they were seven years old said, Some day when I grow up, I'm going to be a spectrum manager. [laughter] It's just a job everyone's fallen in to. They don't teach it in school. And maybe that's something–

APRIL McCLAIN-DELANEY: They had girls in ICT day at ITU.

GLENN FELDHAKE: NASA hosted three of them.

APRIL McCLAIN-DELANEY: So Jennifer, you had one comment.

JENNIFER MANNER: When I was at my 4C meeting, we had three people in the room, including at least three who had been going to the WRC since 1968. So that just gives you an

idea. And they're very valuable members and, god forbid, anything ever happens to them, we and the rest of the ITU will be in trouble. So that pretty much sums it up.

GRACE KOH: Let's bring up Mr. Arrestay[?].

JENNIFER MANNER: He's not the longest.

GRACE KOH: Oh, wow, okay. I wonder who is.

APRIL McCLAIN-DELANEY: So the message is, get engaged, come to be a part of the ITU, gave your forms. And actually I think there are a lot of other countries, unnamed, that send large, large delegations. And I think it's important, thought leadership.

So I think we have time for two questions, if they're short. I don't know if we have a mic. Oh, we do. And a mic appeared.

Q: Afternoon. My name Derrick Hayes. If anybody wants to sponsor me to go to a WRC for the first time, let me know. [laughter] IT's a big deal.

APRIL McCLAIN-DELANEY: The youth summit, you should have come to the youth summit.

Q: I'm open. My concern is, I'm an RF engineer and let's talk about it. The reality is, building these technologies is not easy. Very difficult to support this kind of infrastructure. But the country is shifting. Like in 18 years, probably have a child that's about to be born. He becomes an 18-year-old– I mean, the country is going to shift dramatically in terms of the demographics. I'm concerned that African American, Hispanics and women particularly are just not going to be skilled enough in time to be able to prepare for these ambitions. It's nice, but you've got to have

people skilled to build these technologies. So what are we doing to not lose the talent? How are you prioritizing that in these conferences? Domestically.

JENNIFER MANNER: It's a great question. When I started at the ITU in 1995 – as I said, I was only two – we had 18% women present. In 2015, we still only had 18% women present. And so we started a program called the Network of Women, which I'm proud to serve as one of the co-chairs at the ITU. And our goal is not just to increase, it's try and encourage governments.

The problem is a lot of it has governments willing to support women coming to conferences. And that was a good thing about the hybrid model, was we actually saw an increase in the number of young people and perhaps more diversity from people who attended.

But also trying to work with them to take leadership roles. As Grace said, we have a terrible problem with leadership. We've had one woman head of the WRC in the history of the conference. We've had two women who were at the second level; one was the woman who chaired the WRC; the second is a woman who's from the US, Audrey Allison. And we're poised to have our third woman at this upcoming conference, one of the satellite groups we're hoping from Europe.

But one of the things we're trying to do is to actually, from within, teach women how to take on more roles, speak up, encourage people to take leadership roles. We try to encourage the leadership of the radio communication sector to select women as chairs of groups and give them opportunities. A number of the women I work with in this are here, right in front of me. And try to offer training. And that's something I'm hoping will be hopeful as we move forward. And we have seen some changes.

But I agree with you. I think it's a hard place. It's a very unfriendly place when you– I can never forget, when I went to my first WRC, you're terrified. You don't know anything. It's chaos. And

unless you have someone you can talk to– we also have mentorship programs for CITEL. Carmelo Rivera runs a mentoring program, and that we do for young people, whether it's women or men.

And I think that really helps, giving people a chance. It doesn't teach them a technical skill, but helps them with the political and organizational and giving them confidence to speak up and say, I'd like to do that. Because there's a lot of people who are doing this who are smart and ambitious, they want to be out there. But if you don't know what you're doing, it's hard to raise that.

So I don't know if that answers your question.

APRIL McCLAIN-DELANEY: One more question?

PATRICIA PAOLETTA: Can I jump in on that answer, too? Obviously the wireless industry is booming, whether it's satellite, licensed, unlicensed. And they're snapping up the talent. But if you're an RF engineer and you're willing to go serve your government, going to one of the regulatory agencies, FCC or NTIA or NSF, NOAA, NASA, DoD, that's a great way to get on these delegations. There's a critical shortage of RF engineers across our federal agencies. And if there are openings, that's a good way to start on that path to Geneva and live the high life that we all enjoy. [laughter] It's a great time.

GLENN FELDHAKE: My office is down one, and we have another guy who has, I think, seven WRCs under his belt who's about to retire at the end of the year. So we're hiring.

But to the point you raised earlier, we do get a lot of– well the two things we're here, we're based in Cleveland and people go, "Cleveland?" [laughter] So the fact that the Browns lost with a 13-point lead with 55 left in the– I'm a Bears fan, but still.

People don't want to move to Cleveland, so we're doing a lot more remote hiring, just to try to get some of that talent in. And I think we're doing better at it.

But you mentioned in the early part of your question, we also get a lot of folks who say, I'd love to know what you do. This sounds so fascinating. This is important. They see the importance and they say, "And I've got two school-aged kids and I can't be on the road as much as you're on the road. So I just can't do it." And that's a real practical, logistical problem, and I don't see how that's necessarily going to change.

As much as spectrum is a policy, it's a regulatory, it's a people business. I was saying to Grace the other day, when I was on her delegation, if somebody came to me and said, Glenn, we really want the US to rethink its position on issue blah, blah, blah, I better have been in the trenches with you a bunch of times and know your name. If you're a complete stranger, I'm going to go, What? It's a people business. It is very much building up those relationships over years and years and years to get to know.

So I'm an anomaly. I started in 1996 in the ITU. And part of the reason, I was younger-ish–

GRACE KOH: You were two.

GLENN FELDHAKE: Yeah. Never had kids. I could be on the road all the time. Didn't really matter. But there's a lot of folks, especially on the international side, when you're talking about WRCs and going to Geneva, it is tricky for people. It is a showstopper. It's a difficulty, it really is.

APRIL McCLAIN-DELANEY: The only other thing I'd say is, you had two questions to it. I think that all of the agencies, including NTIA– we would love to have more engineers and more

that go into the fields of coordination and different things. But I think it was also the issue of what you were talking about, of digital equity and skills and how do you reach them, whether it's domestically, which I will say I love our spectrum group. We have a whole broadband group that's rolling out the internet for all. And part of that, we are doing digital equity grants that really focus on the work for skills and the digital literacy skills to make the best use of that connectivity. And that includes digital learning and skills.

And overseas in so many bilaterals I kept hearing, We need connectivity so that our kids and our women can go to school and they could learn about STEM and they could have careers and they could lift up. Because really, all of that connectivity is really about fundamental fairness and equity at the deepest level of giving bridges of opportunity to all, no matter where you live, what ZIP code here or the 2.9 billion around the world.

So I think it's amazing. And the girls on ICT day, I have to say, were really great because there were girls around the world who said, I want to do STEM. And that is a bridge of opportunity.

Do we have time for one more? No, we do not. I'm so sorry. All I can say is thank you to each of my panelists that are here. You all bring such a great perspective. I just also have to say thank you to Charles Cooper and Derek and John Alden and Charles Glass and Bruce because I think the Spectrum Symposium, I joined NTIA on January 31, and it has been an honor and a privilege to be here. Because we touch all things telecom, but the spectrum work that they do here is fantastic, and I think this Symposium is really a public service in itself.

So thank you very much. And thank you to our panel. [applause]

SCOTT HARRIS: All right, you don't think you get to leave now, do you? April, thank you for moderating that panel, and thank you to all of our panel members. I actually thought that was totally fabulous.

One thing they didn't discuss which I've always found fascinating, the truth is, over the years I've seen the most contentious WRC discussions take place within the United States. And somehow, at the end of the process, we come out with a delegation where everybody is on board. I think of it as some sort of mysterious process. I don't know how it actually works, but our delegation at these WRCs – my first one was '95 – it's extraordinary when they come together to represent US interests, whatever they thought going into the process, particularly the people on this panel. And they actually deserve another round of applause. [applause] Because the people who do this work, it really is difficult and it always seems to come out the right way.

So I now have the pleasure of introducing remarks from yet our third Congressional keynoters. As Chairman of the Subcommittee on Communications and Technology and the House Energy and Commerce Committee, Representative Mike Doyle has been a strong proponent of increased coordination among all government agencies involved in spectrum management. He has also been tireless in pressing for legislation that will ensure broadband availability for all American communities.

Please run Congressman Doyle's remarks now. Thank you.

MIKE DOYLE: Good afternoon, everyone. It's a pleasure to be with you today to talk about spectrum policy. I'm heartened to see such a robust group of keynote speakers and panelists discuss the state of US spectrum policy today, and the policy directions this country needs to take as we head into the future.

As you all probably know, after 27 years representing my constituents in and around Pittsburgh, I'm retiring from Congress this year. For the past five years, I have served as either Ranking Member or Chair of the Energy and Commerce Committee's Subcommittee on Communications

and Technology. And I'm proud of all the work we've done, most of it on a bipartisan basis, to advance good policies to connect people across the country to modern communication networks.

This includes a lot of work over the years on spectrum policy. While all of us here understand how important spectrum policy is to the US economy and our global competitiveness, it's not an issue that is top of mind for most of the public. Yet, whether they appreciate it or not, spectrum plays a significant role in their everyday lives.

Beyond its necessity for the operation of the cell phones we all rely on, spectrum also helps us operate baby monitors and garage door openers, stream TV, movies and music, and manage our factories, farms and transportation systems. It's not an exaggeration to say that spectrum helps power the American economy today and will continue to do so into the future.

To remain a global wireless leader, the US must have some spectrum management policies, especially with the exponential growth in wireless data usage we have seen over the last couple of years, and are going to likely continue to see as 5G and other advanced wireless technologies are built out.

This means the federal government, which still holds a majority of this country's spectrum, needs to use its spectrum allocations more efficiently, recognize spectrum sharing as a viable opportunity, and work cooperatively with neighboring commercial spectrum users when necessary.

I am grateful that the leadership of the NTIA and the FCC also recognize the importance of these objectives. And I want to thank Assistant Secretary Davidson and Chairwoman Rosenworcel for their efforts to achieve the goals in the House-passed Spectrum Coordination Act by updating last month, after almost 20 years, their agencies' memorandum of understanding on spectrum coordination.

This effort, in conjunction with NTIA and the FCC's Broader Spectrum Coordination initiative, will help us better understand the spectrum demands of the federal government and should help right the wrongs that we've seen in the past.

But as we think about spectrum management into the future, I have worked with Ranking Member Latta to lay out some key principles that I would like to share today and hope will guide the conversation as it moves forward.

First, NTIA must continue to be recognized throughout the federal government as the entity tasked with balancing the needs and concerns of the federal government.

We must also implement clear rules and expectations for all spectrum users, and those rules and any necessary processes should be based on science and engineering.

And finally, when the federal government makes spectrum allocation decisions, we must ensure that it speaks with a clear, unified voice.

Recommitting ourselves to these principles will lead to better management policies and ultimately better outcomes for both federal and non-federal uses of spectrum.

Staying ahead of our foreign counterparts also requires that we continue to make spectrum available for commercial use, which should include both licensed and unlicensed spectrum. Failing to take such action will hamper our ability to compete with countries like China as we need spectrum to sustain the deployment of 5G, as well as pave the way for 6G and fuel the next generation of wifi, wifi-7.

I strongly believe the lower 3-gigahertz band presents an enormous opportunity for making additional consumer-oriented spectrum available. The House-passed Spectrum Innovation Act strikes the right approach in balancing between federal incumbent users' needs in this band and maximizing spectrum for consumer use.

The Spectrum Innovation Act would also extend the FCC's ability to conduct spectrum auctions, which has been recognized and replicated across the globe. Congress has never let this authority lapse, and it would be a mistake for Congress to do so now.

I would also be remiss if I didn't take this opportunity to champion the candidacy of Doreen Bogdan-Martin for Secretary-General of the International Telecommunication Union. Once again, Ms. Bogdan-Martin truly stands in a class by herself, and I encourage ITU member states to join the United States in voting for her later this month to become the next Secretary-General of the ITU.

And finally, before I close, I want to acknowledge my former staffer, Phil Murphy, who's now Senior Advisor to Administrator Davidson. Phil, I know you'll continue doing great things in the months and years ahead, including on these important issues.

Thank you again to NTIA for holding this important and timely Spectrum Symposium. And I hope you all enjoy the rest of the discussion this afternoon.

Thank you.

SCOTT HARRIS: So our thanks to Representative Doyle, not only for his remarks this afternoon in support of spectrum management improvements, but also for his long record of service to our country.

Our next presentation is from Badri Younes of NASA. Now, I have to tell you, when I was in 5th grade, they called us all into the gym and they brought out these large TVs and we all watched the first Mercury launches. And so, I'm a pushover for anything that NASA wants. And I think Badri actually has the best spectrum job in all of government, and I'd trade with him in a heartbeat.

He is the Deputy Associate Administrator for Space Communications and Navigation where he oversees the spectrum strategy that NASA employs as it looks over the horizon, every many horizons actually.

He's going to discuss NASA's current missions, most of which you will probably know something about from reading the papers. And we have him on video today. If you will roll Badri's remarks, I'd appreciate it. Thank you.

BADRI YOUNES: Hello, this is Badri Younes. I'm the Deputy Associate Administrator and also the Program Manager for NASA's Space Communications and Navigation. I'd like to thank NTIA for inviting us to this forum to provide an overview of our innovative future communications strategies and plans for space communication.

I'd like to thank the other panelists for participating. Definitely we all share in appreciating the value of spectrum. It's a critically enabling capability without which I can tell you NASA cannot do its mission. We rely on remote sensing to do much of our science. And remote sensing relies on spectrum. So spectrum is so critical.

And I would like to thank NTIA and the other agencies, as well as the FCC, who have worked with us in the past to ensure that spectrum is widely used such that we all can do our mission. I'm hoping that today's panel set the stage for future-looking discussions between not only government-to-government, but also government and commercial space activities.

Let me present to you our vision of space in the future. As we work on commercializing space and creating more commercial opportunities up there, the environment's going to get a little bit more complicated and more complex. The way we do business now will not be feasible for the future.

Additionally, NASA is moving forward with the acquisition of commercial services for space communication and navigation. So as we look into the future, we need the kind of capability that will allow us to move between different providers and be able to reconfigure ourselves, both in frequency and also in waveform.

We are looking at a highly complex environment that the traditional way of scheduling services will not work. We need some cognitive capability at the mission level to operate autonomously. Autonomous navigation and autonomous communication or operation will be critical because people are slow; people can make mistakes; people cannot respond in real time. So we are looking at the future where we can operate autonomously and also navigate autonomously.

So as we commercialize our services, the kind of support our user will need has to be robust and resilient, and also they need to be assured of access. And not only the kind of access where there are glitches in the link; they need to have a seamless roaming capability between different systems. You all remember how roaming used to be on the ground. Now we don't feel it, but it used to be a problem before from a cost and from a technical perspective. Now roaming is kind of seamless. You go from one area to the other area and you don't feel it.

Additionally, we all have and share a huge appetite for bandwidth. And the spectrum is getting so congested, and the more we get, the more we want. So the lower frequency bands are becoming heavily congested and we'd like to protect many of them to enable us to still do our

operation for passive and active sensing. That's why we have been pushing the technology to move up in the frequency band, from Ka and beyond, all the way to the optical range.

Spectrum remains a big challenge if we are to roam in space going from one system to the other. In the US, definitely, we have the bifurcated process where you have government regulated differently. At the same time, you are talking about, from a scientific perspective, we are mixing commercial things with scientific things. So the spectrum implications are the kind of things that we need to work with you guys and with the regulators on how to remedy.

Definitely, our vision for the future is a user that has the resiliency and the flexibility to move between networks unimpeded by the regulatory chopped waves and to be able to have a seamless operation.

Some of the challenges that we are really working very closely on mitigating now are the technology. We are heavily invested in technology. We are working on different initiatives, as well as on the standards. And we are looking at the spectrum. From a technology perspective we are looking at the kind of technologies that will allow you to move between systems and be able to reconfigure yourself or the capability both in frequency and waveform.

Standards, we are working with everyone. We used to work independently, the scientific community from the commercial community, on different standards. So now we are moving forward to building common standards and adopting each others' standards. These are critical to allow each other to talk to each other and to be able to get that cross-support between two different systems.

And also the spectrum access is so critical. Without the authority to operate and to access, we cannot operate. These are showstoppers. So we are looking at how we can access spectrum, and in particular enabling the commercial system to support not only ground-based and suborbital-

based users, but also to support space-based systems, such as the system that NASA has. Much of our operation is in space; we go from LEO to VEO to GEO to the moon and beyond, to deep space. We have spacecraft that have gone beyond the edge of the solar system, and they are still very much alive and sending data from the interstellar area.

So SCaN is actively working all of these elements, these technology standards and access, to realize that vision I showed you earlier.

Just to show you how serious we are about commercializing our services, we recently awarded six Space Act agreements; you can call them contracts, to six different companies to demonstrate the feasibility of getting commercial services, services that were developed to support ground- and suborbital-based users, to see how good are they supporting a NASA user. A NASA user is a user that, in LEO and beyond, going at the speed of 17,000 miles an hour. Definitely this provides some complexity compared to a ground-based user or suborbital user, going from stationary to maximum speed of a few hundred miles per hour.

So we don't know how well they can meet our need, and once they log on to our user, how long can they track that user. So that's why we are working with these contracts. They are six separate and different providers. They vary from VEO to a LEO to a GEO stationary-based provider. And we are going to study what classes of users they can support now, and if they can support some of our users now, we are going to effect that migration soon after.

And what kind of modification? If the business case there is feasible, they can make to their system to support the other classes of users. And if there are classes of users that cannot be supported even with the modification, to identify them now and to work with industry on finding solutions, such as hosted payload or other means.

So building these capabilities to work, realizing that environment and also to pursue that interoperability is so critical because we would like our users to still roam in space and get support from any of these providers, as well as other providers.

I talked how important technology is in shaping the future and enabling that interoperable environment and to allow us to overcome the regulatory constraints. NASA is heavily invested now in a multilingual, or polylingual, modems and payloads that can be reconfigured on the fly to any frequency within a certain frequency range. We are targeting the Ka-band. And also be able to reconfigure it in waveforms. These are software-defined radios. And we are working on cognitive technology that will allow us to manage that access and to manage the capability from space without a human in the loop. We are still targeting the autonomous operation.

So both the cognitive technology, the cognitive radio, as well as the multilingual, or polylingual, payload should allow us to do that. This way, we can move between systems because different providers not only operate on different frequencies, but also different waveforms. So to be able to access them, we need to talk their at frequency using their language.

So this terminal has already been demonstrated at the surface level, and we are targeting working with the Applied Physics Lab to demonstrate, to build a flight-capable unit that will be flown in '23/'24 timeframe.

I talked about optical communication. Our appetite for bandwidth has moved us up in the frequency range. We used to operate at the low frequency band. We moved to the S-band, we moved to the X-band, we moved to the Ka-band. Now we see ourselves making a quantum leap into the optical domain. Definitely optimal communication, not only provides us the bandwidth, but will also provide us the regulatory-free environment, or the environment that's free of regulation, where we all can operate at the same wavelengths unimpeded by regulatory constraints.

But we are not just looking at optical communication for just that purpose. We have the declared the 2020s as the decade of flight where we infuse optical communication throughout our operation, and hopefully the commercial sector will buy in to that and will start to provide optical link across the various platforms they have up in space.

But we are looking at what's after. What's after the optical communication is going to be quantum network and quantum communication. We would like to unlock the full potential of quantum technology and application, not only for scientific purpose, but also for spectrum purpose and also for resiliency and robustness.

NASA cannot do it alone. It's going to require a public/private partnership. It's going to require all of us, government agencies and commercial providers, to work together. In our pursuit for interoperability, we'd like everyone to adopt the concept, to enable users to roam in space seamlessly, without interruption. The value of the service will grow exponentially if we all come together as a single community of providers or interests and users.

So we are looking forward to working with you all on this vision for an interoperable space and to partner with you on enabling that. NASA would like to commercialize all of the routine stuff, all of our common NAF services where the commercial sector can provide that service. In areas where the commercial sector cannot, then we are going to still have this unique capability.

We'd like to focus our research and development of the next-generation capability, the next-generation communication and navigation technology. So by relying on the commercial sector for operation, we can free up many of our resources to folks on technology and the next step forward.

Again, it takes a village, it takes a country, it takes a globe, all working together to advance the state-of-the-art to the next phase, to the future. [04:33:12] to collaborate with you all, and we are hoping that jointly we can push the technology envelope. We'll keep on pushing it.

Thank you for having me. And hopefully I can come back in the future and talk with you about our vision and our accomplishments. Many thanks. [applause]

SCOTT HARRIS: So Badri's presentation made two important points; one, I think, emphasizing what folks were talking about this morning. There's an awful lot of innovation going on on the government side of spectrum use; it's not just on the commercial side. The other point he made several different times is how it's not just NASA using spectrum in space. They're doing a lot through the commercial sector, which is a perfect lead-in to our next panel, which will be led by OSM's Bruce Jacobs, who I'll call to the stage, and he can introduce his panel members.

BRUCE JACOBS: Thanks. I thought Badri's presentation was excellent. A lot of information about what NASA's doing and some exciting stuff.

I've been involved with space and spectrum issues for close to 40 years and I can't think of a more exciting time. Industry is more dynamic than ever, more innovative. And government, as you heard from NASA and others, is taking advantage of that innovation and advances in technology in order to achieve our missions – protecting the environment, advancing science, helping grow the economy, and providing for national security and public safety. Whether it's the Webb Telescope, or the latest GPS satellites, or improvements in tornado and hurricane forecasting, space operations and the radio frequency spectrum that missions depend are front and center, as all of you know.

And to help highlight these government missions, we're fortunate to have a great panel of government experts who work on these issues every day. They'll describe some of the spectrum-dependent missions that their agencies are undertaking and the partnerships that they're working on to develop those. And we'll discuss some specific spectrum-related issues of concern.

But before I introduce our panelists, I want to do a quick plug for a publication that NTIA released last summer that describes the wide range of space-based operations that depend on the use of spectrum. This is a 100-plus-page report describing commercial, government and academic uses of space, uses of frequencies in space, and the specific frequency bands on which they operate. I think it's a great accomplishment that we worked with the private sector on. FCC, a lot of the agencies contributed information about their operations. And I encourage all of you who have an interest in this area to take a look at it. Obviously, it's on the Web, on the NTIA website.

So without further ado, the four panelists we have, in alphabetical order by last name, RJ Balanga, Deputy Director of Spectrum Policy and Planning at NASA; Reza Biazaran, Deputy Director of Radio Frequency Management Division, Office of the CIO at NOAA; Kathryn Martin, Deputy Director of Partnership and Engagement in DoD's CIO Electromagnetic Spectrum Enterprise Policy and Programs; and last, but not least, Ashley Vanderley, Senior Advisor to Vision of Astronomical Sciences at NSF.

What I'd ask each of them to do is to just, in turn, say a little bit about what their agencies do that are spectrum-related, space-based spectrum-related.

RJ BALANGA: First of all, thank you, Bruce, and thank you, NTIA, for having us here. I'm glad to be here with a bunch of distinguished panelists. As Badri said earlier, this is a critical point for NASA. We're engaging with a lot of new emerging technologies. There's a lot of commercial partnerships with non-government, as well as academia. There is a paradigm shift

that's also ongoing, as Badri mentioned. We're moving away from government services and government systems, especially TDRS, tracking data relay services, and we're going to satellite services. And there's a challenge in that as well, but we'll get to that in a few more questions.

Not only from a commercialization standpoint for that paradigm shift, but as you all know we're going to the moon. Artemis 1 is going to be launching in the next couple weeks – hopefully, fingers crossed. And we'll be sending the first woman and next person of color to the lunar surface. And we need frequencies for the communication to develop a lunar architecture there, as well as a navigation architecture around the moon and the sized[?] lunar environment.

Then NASA also leverages a lot as another paradigm shift to small satellites. Small satellites, because of their low cost and their quick ability to turn around and develop satellite systems to support our missions, we've been leveraging on that. There's some additional challenges and obstacles we need to address there.

BRUCE JACOBS: Reza, do you want to speak NOAA's mission? I know earlier on, Zach Goldstein talked a little bit about what NOAA does in space and using spectrum, but maybe you can amplify that.

REZA BIAZARAN: Sure. First of all, thank you very much, Bruce, and Charles and dear hosts here, thanks for having me and the rest of the panelists here. I have to say I'm sitting right next to a gentleman representing an organization that sends folks to the moon, so I don't know, I guess I have nothing. [laughter]

On a more serious note, I don't want to repeat what my boss said in the morning, but to just add on to what Zach said this morning, as far as spectrum-dependent activities in NOAA is concerned, remote sensing is because the primary objective, to characterize the earth and the

earth's atmosphere and above the earth's atmosphere as far as space-related activities are concerned.

So going around that primary objective, anything that supports that mission, if they do relate and depend on spectrum, is basically on that end, is accounted for. The data collection and data dissemination service that supports collection of data from the observations and dissemination of data to help to primary purposes basically weather forecasting on a short-term basis, as well as climate observation and climate modeling on a long-term scale, is basically what the primary objective of the spectrum-dependent systems are in NOAA.

BRUCE JACOBS: Kathryn, Reza wasn't intimidated by sitting next to NASA; sitting next to DoD, maybe. [laughter]

KATHRYN MARTIN: We are all one family here. Thank you, Bruce, thank you, Charles, and the rest of NTIA for hosting this symposium. My name is Kathryn Martin and I'm with the Department of Defense Spectrum Policy Office, responsible for partnership and engagement. And it's a pleasure to speak today on the topic of not simply space, but spectrum in space. And without DoD, it's pretty interesting because we often think of spectrum as being congested, contested and complex; like, how can we achieve our mission with this strategic asset when it's always under demand. It's been contested, it's been congested and complex. How do we work it?

Well, the same is true with space. Within DoD, space is critically important to our ability to achieve our missions. And that is becoming increasingly congested as more space-faring nations and adversaries and friends alike are taking advantage of space. But also for us to do our missions, we're relying upon space to enable our warfighters and our combatant commands to be able to do what it is that they need to do. And there's a great deal of innovation, both within space and the spectrum world, in large part and in concert with commercial industry to make sure that it's happening.

But from my vantage point and from our vantage point in this room, to see those two worlds overlap, where you have something that's contested, congested and complex intersect with something else that's contested, congested and complex makes for C-to-the-square-to-the-cubed; you're trying to really figure out how to negotiate and establish policies that conserve both industries, both things well.

But just to step back and to say how it is that DoD uses space, it is viewed as a vital interest. There is a US Space Force. There is a Space Command. And having superiority in space will enable DoD, and our US government writ large, our ability to maintain our national security and superiority. And it's not simple.

But I wanted to just touch upon the different types of uses we have. And some of this was brought out in the NTIA report you just referenced, but GPS itself is probably one of the largest and most important uses of space for DoD. We use it for navigation. We use it for precision. We use it for many of our tactical and strategic operations, as we all do as consumers, but also from a DoD perspective, it is critically important.

We also use it for communications command and control. Whether it be high secured communications among different parts of DoD, something that needs to be secured, we often use satellite communications to meet that. But we also use satellites for broadcasting or for the wellness and morale-lifting phone calls that troops have. Just basic communications command and control, we often rely upon satellites and the need to protect that space. And as many of you in the audience know, clearly the US DoD relies upon its industry partners in order to enable that.

Similarly, to my partners to the right, we use it for remote sensing. It's important for the DoD to know what is going on at any point in time, whether it just be for keeping an eye in terms of what

our adversaries are doing, but if there's any sort of nuclear underground testing; we need to know that. Missile tracking, missile defense, there are a wide variety of purposes. So we have both active sensors, passive sensors keeping track of what's going on.

I have recently learned we have our own weather system. [laughter] It's not a standalone system; we often rely upon the weather forecasting information we get from other systems as well, but in order for DoD to succeed globally, we do need access to moment-by-moment information about weather and other information that's going on.

So it's remote sensing, it's communications. And I thought just to give you a breadth of what also is going on within the Space Systems Command – because they're often looking at capabilities, ensuring that we are not just on par with our adversaries, but a step ahead, let's just say – I want to touch upon six very quickly, areas of acquisitions and offices:

There's Launch, which is an entire office dedicated to the assurance of access to space.

We have military communications and PNT – positioning, navigation and timing. That its own world, GPS, understanding how to communicate. That would include the tactical satcom, strategic satcoms, GPS, narrowbands, satcom networks, et cetera.

We have space sensing and reconnaissance, missile warning, missile tracking, all of that.

We have battle management and C3. There's a fair amount that's not publicly disclosed, but a lot of that deals with how do we ensure that from a position of space that we're able to neutralize to remain a step ahead.

We have space demand awareness and combat power. It's important to us what is going on in space at this time and how can we keep track of it.

And there's a great deal of innovation and prototyping, as well as warfighter integration.

These are just a sample of the different programs, within DoD, as sure as I'm sitting here, I'm sure there are more that aren't quite active in ensuring that the US military writ large has access to space in a way that supports and enables our warfighter.

And spectrum is a very important component of that because, really, without spectrum access, you really don't have much going on in space. You need them both together. So working closely with industry is critical to our success; it's not a one-or-the-other type of effort. These are both important topics.

BRUCE JACOBS: Ashley, tell us about the scientific uses of space.

ASHLEY VANDERLEY: Thank you. Earlier in the panel when Ambassador Koh was speaking and she said spectrum is not just the lifeblood of communications, it's the lifeblood of the entire future economy, I thought it's actually more than that – it's the lifeblood of all discovery. If we're going to learn, if we're going to expand our view of the universe, we need spectrum.

So really appreciate the opportunity to speak for the National Science Foundation because people don't often think of us on par with space systems such as NASA and NOAA and DoD. But when we actually think about all of the different systems that we have and the importance of spectrum to those systems and our ability to get that new knowledge and new discovery, there's lots of touch points.

So just a couple points I wanted to raise as we're thinking the systems that NSF has, two things I wanted to point out. One, there are varied purposes for space systems. So oftentimes, people

come from a perspective just thinking about communications or weather forecasting or defense. But of course, there's also the scientific purposes. And you want to think about that whole ecosystem of uses.

And the second one is one that Glenn Feldhake touched on earlier, is the broad infrastructure that you actually need to support a space system. So not just the satellite in orbit, but you also need the ground infrastructure, the tracking of those satellites, which might be optical telescopes. You need the communications. You also need to have a really good ability to detect solar flares and space weather so that we can protect those space assets.

So this is where the National Science Foundation comes in in terms of funding and trying to understand the basic research and development for all of these basic fundamental questions to get better.

So generally, we've been maybe a little bit lagging because we try to fund blue-sky research. But really exciting that our director announced the new TIP director for translation, innovation and partnership, to try to take some of this research more to speed and to partner even faster to get some of this research connected with the needs of our other federal agency partners and industry.

So I wanted to note just a couple example systems the NSF has that contribute to space operations and use spectrum. One example that I really love because it shows the unique aspect, is, if you look at widely distributed radio astronomy array systems, a technique where you separate them so it's almost like you have the telescope the size of the earth, when this was first developed, people were just interested in looking at galaxies at higher precision. But it's actually that network of measuring galaxies all over the sky that gives you the most precise orientation of the earth, that gives you the earth orientation parameters that connect to GPS. So it's really, really important and kind of critical for us.

What's interesting is, GPS causes interference to radio astronomy. We can't really observe in those bands anymore. But at the same, the radio telescopes are giving us the critical information that you need for orientation.

And then you can think scientists are very creative, so atmospheric scientists have used GPS signals to better understand the atmosphere as the GPS signal comes through. So even if we have new interference, maybe there's going to be innovative ways to understand or to study something that we haven't before.

And furthermore, it touches on, I think, something that you're going to talk about later, RJ, we can't do certain radio astronomy observations from earth anymore, but maybe that's where we can take those observations to the shielded zone of the moon.

So as we're thinking about the whole ecosystem and how these different pieces fit together, that's just where NSF comes in in terms of the basic research, funding the research, also some of the facilities; and then, as the young man asked in the last session about workforce development, making sure that we have the systems in place to train folks to be ready for these positions.

Two other things that I'll mention really, really quickly when it comes to example systems. The space weather and solar flares, again, are really, really important. And so, again, this is an example of, with the recent Daniel K. Inouye Solar Telescope, it's not actually depending on spectrum, but that's going to help us understand magnetic properties of the sun and help us with prediction; that, combined with the GONG Network of six telescopes that NOAA is now operating.

And so, those kinds of things, combined together, again are going to give us that whole ecosystem that we need for a space system for the United States moving forward.

I think some of the other comments I will save. But again, I wanted to mention – I think Glenn had mentioned it very strongly and made this point – that even if you don't think that a system depends on spectrum– so for example, we have telescopes in Antarctica that are looking to understand the cosmic microwave background radiation, very far edges of the universe. One of the big challenges that they have is getting the data from Antarctica back to the United States to process that data. Terabytes and terabytes, petabytes of data coming in. And so, again, that's a communications challenge to then get to the science discovery point.

So there's a lot of really interesting interconnections there. And that's why we're interested, not just from the science perspective, but also partnering with the computer science and the engineering directorates and across all of NSF have to bring all of that research and development and to find those solutions across all the board and to partner with all these challenges.

Thanks, Bruce.

BRUCE JACOBS: That's great, I really appreciate it. The best part of this panel is learning about all of these things. There's so much going on, and it all depends on spectrum.

A theme has been partnerships, commercial, academic. And Badri certainly mentioned it. I know it's front and center for the agencies. It makes a lot of sense. So I want to give you guys a chance to talk a little more about what you're doing in those areas, the pros and cons, what challenges you're finding. Do you want to start off, RJ?

RJ BALANGA: Sure, thank you, Bruce. As you mentioned, as well as Badri, the commercial industry has really taken a forward-looking stance in developing systems that will operate in space and continuing not only government operations, but also their own endeavors. In future, there will be tourists in space, as well as mining on the moon, and much more.

The last time that the ITU Radio Regs were updated on the lunar environment was 1979. So it's about time that we start looking at updating those Lunar Regs soon. And I'm really happy to see that within the ITU, US ITU, the process that there are actually a few agenda items or proposed agenda items that will be going to the ITU. We just had to ensure that we scoped the proposals correctly going into 23. So we're not overly looking to too wide of a scope into some of the lunar activities or else it's not going to gain traction at the ITU level. We don't want to make it too small either or else we might be missing opportunities for other aspects out there.

BRUCE JACOBS: What's NASA doing with the commercial sector for lunar?

RJ BALANGA: Right now, we're doing a lot of demonstrations on the lunar surface. Grace Koh was here just a few minutes ago. With Nokia, we're establishing the Nokia tipping point which will do a demonstration of a base station and a lunar rover in space. But there are challenges to that as well. We can operate and we have approval and authority to operate right now on an NIB – that's the non-interference basis – but we need allocations and service allocations on the moon so those types of typically or traditional terrestrial type services can be used on the lunar surface.

BRUCE JACOBS: Other commercial efforts that you want to highlight? I know Badri listed a bunch.

RJ BALANGA: Yeah, Badri listed a bunch. We just encourage continued discussions with NTIA and the FCC. Again, we need advocacy for the space and lunar missions, not only within the US, but then the US taking those positions to the ITU.

And as Badri also mentioned, in order for us to make this paradigm shift to commercializing in the future, NASA's developing these polylingual/multilingual radios so we can really and truly roam in space. Just like how you can take your cell phone today, no matter what carrier you're

on, and roam in different areas of the United States or roam globally. We want to do the same thing in space.

BRUCE JACOBS: Thanks. Reza, do you want to highlight any commercial efforts that NOAA is undertaking?

REZA BIAZARAN: Before I do that, I guess I would like to emphasize the fact that commercialization as far as remote sensing applications is concerned is nothing new as far as launching capabilities or instrumentation. This is something that we have heavily relied upon on industry, which is advantageous because by default, and I know I work for the federal government, but I have to admit that as far as implementation of technology, commercial industry is by far ahead of the federal government. So from that perspective, commercialization is nothing new. but when it comes to acquisition and the formal acquisition process in the federal government, that might be something that is relatively newer than just the implementation aspect of it.

So from that perspective, we have started– for example, one primary example would be the system of satellites or data collection systems or Argos is one example. That's on the data collection side of the remote sensing instrumentation. On the remote sensing side is also another example that I can provide.

BRUCE JACOBS: Those are ongoing projects?

REZA BIAZARAN: They are, yes, they are.

BRUCE JACOBS: I know the Defense Department has bought commercial services for a long time, but I think there's probably increased emphasis on new approaches. Anything you want to highlight there?

KATHRYN MARTIN: A couple things, I suppose. Just to speak broadly, yes, the DoD has traditionally relied upon the commercial industry, but now I think more than ever, to rely upon them not simply just for services and access, but also new ideas and innovation. And that's really what enables DoD to remain competitive and to move forward.

I would also, separately, just in terms of partnerships, echo what the DoD CIO, the Honorable John Sherman mentioned this morning, that there's a fair amount of discussion or studies within DoD that is bringing industry for the inverse studies for the use of the mid-band 3.1-3.45-gigahertz band. And so that's somewhat new, to kind of bring in that type of dialogue.

But I would also like to emphasize and just echo the importance that we have in how we value our relationship with NTIA, other federal government agencies and the US government policymaking process itself because it's really these relationships and these discussions – I think as Glenn was mentioning earlier and what we've been hearing – it's really what enables us to be successful.

And so, it's through NTIA that DoD and other federal agencies are able to work successfully through, like the FCC's commercial space launch proceeding. That's one way where the partnerships are moving forward.

It's perhaps a broad interpterion of partnerships and working with commerce, but it's very important to us.

BRUCE JACOBS: I think that's a good way to say it, a broad interpretation of partnerships. Good. How about NSF? You guys work particularly with academia a lot. Is there more of that going on? Does it look different?

ASHLEY VANDERLEY: We have a lot more of that in spectrum in the past two years. One partnership that I wanted to highlight, we have a new funding program, the Spectrum Innovation Initiative. And huge thanks to both NTIA and FCC. So we signed an MOA with them to work and partner because we wanted to make sure that we were putting research dollars in places that were advancing the goals that NTIA and FCC had and we weren't getting the way, but we were really helping, once those key challenges were identified, that we could publish solicitations and "dear colleague" letters pointing academia to that.

So out of that effort, we have the first National Center for Wireless Spectrum Research, SpectrumX. It has dozens of institutions involved, including more than a dozen minority-serving institutions and many folks from industry as well. So that's one place that academia and industry can come together. They have workforce programs. We're really excited about that. They're just in their first year so we're really looking forward to seeing what comes out of that center.

Additionally, when we think about things like dynamic sharing as part of the Spectrum Innovation Initiative, we have a new program to try to push the envelope on dynamic sharing. So the great work that has been done in CBRS, is there a way we can expand that, extend it to other frequency ranges, and actually not just do modeling, but actually testing NC2[?] and demonstrating that it works, not just on paper, but in reality.

So that program has stood up and awards have been made this summer, so we're really excited to see what comes out of that and continue to invest to see more of that dynamic sharing that's going to be necessary if we're going to have more efficient use of the spectrum.

And then that brings me to just one other example that I'll share in terms of partnering. So there is some expected issues that come up in spectrum. So with the large constellations of satellites, we all have done the studies so we knew what to expect from the radio downlinks and our radio telescope. So we had done some precoordination and working on coordination agreements with a

number of companies, but everybody was surprised, including astronomers, that there was the optical impact of reflections from the satellites and how that impacted astronomy.

So I think that's another good example of partnership because of the coordination that had begun, we just continued to talk and work with these companies to say, what are the challenges, host workshops to really get all of those challenges and problems on the table, and then try to, again, fund the research to specifically solve whatever problem it is at the technical level.

So that's just another example. I think some of the problems are close to being solved. Of course, some are going to take longer. But I think it's really a fantastic effort and a good example of that kind of partnership.

BRUCE JACOBS: I think you were describing to us earlier, before the symposium, some work that's being done to cancel the interference from NGSO constellations, and that sounded like some interesting work that would have applicability a lot of places.

ASHLEY VANDERLEY: Yeah, absolutely. One of the kind of cutting edges when it comes to spectrum is not just getting rid of it, but being able to process your data through it. So in astronomy, you're actually seizing those that are below the noise level because you understand the noise level so well. But in some cases, if the signal's bright enough, it can actually just cause ripples in your band pass. There's no way that you can actually characterize if it becomes non-linear.

But if you could actually cancel, like noise-canceling headphones to some degree, and you could reduce it to a level that you could actually characterize and understand the noise and then model it, then you could actually still do your mission at the same time that you're dealing with this other source of interference.

So it's not just a matter of having completely clean spectrum, but also understanding and having really good post-analysis tools to get below the level of the noise to whatever signal it is that you're trying to detect.

BRUCE JACOBS: That's an exciting effort. Good luck with that. Definitely keep us posted. So a few topics of interest to me that we've talked about before this symposium, and hoping you guys can elaborate on a bit. We talked about TDRS and commercial replacement of it, and for somebody who's only been peripherally involved with all this, TDRS is a constellation of GEOs and LEOs that provides a lot of the connectivity for objects in space, for satellites and government operations. Been there for a long time and NASA, as I understand it, is planning to eventually phase it out in favor of commercial use. And one of the key ways to do that would be to actually communicate with existing commercial satellites or new commercial constellations. So if you could talk a little bit about sort of what that represents and what some of the issues are space-to-space links.

RJ BALANGA: Again, as we move over and we make this paradigm shift from government services to commercial services, there's a lot of advantages in that. One is that commercial industry will continue to grow and there's going to be targets of opportunity for us to be one of many customers to those satellite services. And instead of us developing and continuing to develop and maintain the TDRS, it just seems more advantageous for us to go that route, to leverage on those commercial services.

But from a spectrum standpoint, space-to-space links are not regulated or there's no regulatory allocations for that. We're currently mitigating that right now. Within WRC-23 that's coming up next year, the WRC, there is an agenda item on the table, Agenda Item 1.17, that is looking at fixed satellite services and finding those ISL or intersatellite links for that use.

And then moreover from that, there is also an agenda item for WRC-27 – fingers crossed that it will move and progress from WRC-23 to WRC-27 – Agenda Item 2.8. That will also look at frequency bands for mobile satellite services so that we can take advantage of those services and partnerships out there as well.

But we want to also applaud the NTIA and FCC. Through our US preparatory processes for the WRC, NTIA and FCC have been strong supporters and advocators for those satellite-to-satellite links in WRC-23, as well as WRC-27.

BRUCE JACOBS: Great. I don't think any of the other agencies are particularly focused on ISLs, is that right?

REZA BIAZARAN: We actually are.

BRUCE JACOBS: So NOAA's looking at it, too?

REZA BIAZARAN: Yeah, absolutely.

BRUCE JACOBS: Good. Another relatively narrow question: I know another topic that tends to come up, particularly with the idea of commercialization and using hosted payloads is the issue of, is any authorization the provenance of the FCC or NTIA, this split authority in the US? I know that issue has come up, some with NOAA, some with NASA, I think with NSF, although not as often. Do you guys want to speak to that at all?

REZA BIAZARAN: Absolutely. That's definitely an issue worth talking about, as well as when it comes to commercialization of activities. As far as NOAA and remote sensing activities are concerned, it's a very critical issue. And I think part of it, or the bulk of it comes from the fact that we are actually right in the process of this mindset shifting from a set of activities that used

to be regulated by federal government, federal acquisition for the most part now into the commercial industry. So that mindset is shifting and as a result there is a little bit of hassle involved.

This topic is actually of interest to me because in my previous life I used to work as an RF engineer and test engineer. So when it comes to authorization and the authorization process and how it actually corresponds to how the FCC actually mandates and executes equipment authorization as opposed to how the federal government does it, which correspond and are interrelated, but they're different.

When we actually move from total 100% federal acquisition type work that does work on a spiral work and on a stage-by-stage as opposed to how the commercial industry does it, so the authorization aspect of it is something that also needs to get shifted when we move from basically a set of work that was 100% on the federal government and federal acquisition as opposed to work that is primarily on the commercial industry and they way that they do business.

So equipment authorization from that perspective is something that's also in this moving process and has to get shifted.

So one thing that is also important is the fact that when federal government does the acquisition, spectrum supportability is a primary part of federal acquisition. And how it actually works, we actually go, and as the stages, or those milestones as federal acquisition folks are more familiar, as those stages progress, we do spectrum supportability at every stage and make sure that this is implementable, is from a spectrum dependency type activity can be supported.

So on the commercial side, they also do their own sets of spectrum supportability activities but they don't necessarily, are not all the time correspond on a one-on-one perspective. So that's one of the areas.

BRUCE JACOBS: Not the sexiest area, but definitely one that you don't want your project to be about to launch and not having the authorization because there's a dispute between FCC and NTIA over who should be doing the authorization or who shouldn't be doing it. A topic that I think is one that we all need to pay more attention to.

I've got a general question to throw out to you all, and that is, does your agency need more spectrum? I don't think the answer is necessarily obvious. Why don't we start with Ashley?

ASHLEY VANDERLEY: Yes, but let me caveat. Advances in every field require broader spectrum. If you think about astronomy as an example, anyone can operate if you don't cause interference to others. So passively they've been able to operate, essentially especially up in the millimeter ranges, without too much interference just because folks had not moved up to those bands yet. As there's more and more congestion, there's an increased need for having a place that you actually can still access that spectrum.

And so, I would say one of the things that's really needed for science is more geographically protected areas where maybe you don't have access to all of the spectrum all the time, but dynamically at certain times you are able to access certain pieces of the spectrum. It's really critical for us to be able to make science discoveries for the coming decades to think in that mindset.

An example, if you think about the really exciting recent gravitational waves that were first detected and folks were looking for an electromagnetic counterpart, that's an example. This is incredible; we all want to be able to detect this. So I think about it a little bit like the marathon in New York City. We're not going to close down the roads all the time, but there is a special reason that maybe we want to come together as a community and a society and say, Yes, let's shut them down this day; this is important enough.

And so, I think as we think about science and discovery and being able to continue to do those things, broadband internet, communications, cell phone, it's important for scientists as well to be able to reach all the students. But at the same time, if we want to still be able to make those scientific discoveries, we're going to have to move to this more dynamic model and be able to protect certain geographic areas for that scientific equipment.

So I think encouraging us to think in that way is going to be really, really helpful moving forward. And so, keeping that in mind, that it's not just one of those systems, not just communications, not just weather forecasting, but kind of broader bandwidths and more sensitivity is how you kind of push the envelope in all areas, including scientific discovery.

So absolutely, there's needs there.

And one other thing that I'll just say is, someone said this morning that it's hard to quantify the value of spectrum, but it's also difficult to really quantify how much work it takes to do all the calculations to show the impact. And so, that's something else that we want to keep mind as we continue to try to make more spectrum available, which is really important for communications for broadband internet, but also to think about, okay, is there a way that we can do this flexibly, agile? Can we use new techniques, as we were talking, of machine learning.

Thinking about decades into the future, someone said a 10- or 20-year plan; we really need a 50-year plan. Where do we want to get in 50 years? And now let's all work towards that. There's going to be hiccups along the road, but maybe we can have these small test pilots where we solve problem after the next. We're not going to solve it all at once. So that's one thing, definitely.

We need more spectrum and we're going to have to be creative and kind of move in those directions to be able to still be able to science and achieve all of these things we're trying to achieve in the coming years.

BRUCE JACOBS: Thank you. Just to be clear, you're saying more spectrum within the quiet zones, but not more spectrum outside the quiet zones?

ASHLEY VANDERLEY: For astronomy, I would say more spectrum within– we only have one quiet zone; it's where the Green Bank Telescope is in West Virginia. So the telescope in New Mexico, the Very Long Baseline Array, they do not have the same kinds of protections. So I think we do need more protections for those particular telescopes.

There are also a couple bands that are really important. Like Glenn Feldhake was saying, certain bands you can't move because of Mother Nature, like the neutral hydrogen band. So that's a great band that all universities can put up a telescope and show their students. So there's a couple of bands you would think, these are important to protect across the board. But I think beyond that, if you really think about cutting-edge and scientific progress, there's half a dozen, a dozen places that you'd really want to, I think, focus the protections moving forward.

BRUCE JACOBS: Thanks. Kathryn, do you have any shopping lists that you're willing to share with us?

KATHRYN MARTIN: Yes, I do. The DoD shopping list is long. Similar to NSF and Ashley, I don't know that I would view it simply as, we want more, we need more. What is clear to me is, DoD is a customer of so many different types of technologies – remote sensing, weather forecasting, communications. It's not simply just mobile industry versus satellite, et cetera.

Almost all industries experience a great deal of research and engineering and innovation. But they're also using spectrum quite efficiently. We want to encourage that. We need that. We need to continue to use that.

DoD does have– the shopping list isn't quite more spectrum, but it is, how do we use the spectrum; how can we share? How can we ensure that our missions are protected in the way they need to be protected? How can we make use of all the new technologies that are doing wonderful things in the different bands?

And so, it's not simply more; it's more of the how and ensuring that our needs can be protected and we can work in a new, complex environment.

BRUCE JACOBS: Thank you. How about NOAA? Does NOAA want more spectrum?

REZA BIAZARAN: Yeah, I do have some points, but I'll wait for RJ this time; I'll let him go first.

RJ BALANGA: Thank you, sir. Just like Ashley and Kathryn had mentioned, NASA answers yes and no. Do we need more spectrum? Yes. As we leverage more and more commercial services, the commercial industry needs more spectrum. Which was typically in the US because of our bifurcated regulatory system, we have allocations set aside just for commercial-exclusive and for federal-exclusive. Now we're trying to ensure that as we bring in more, there's more commercial entities out there, that there's ample spectrum to support them, not only for their needs but, again, because we're going to be a customer of them, to support our missions in the long term.

As you know, S-band, 2200-2290, is getting very congested. And new commercial folks are coming into that band through new proposals and proceedings from the FCC. And I as these entrants are coming in, NASA's taking a hard look at where we need to be.

So we are starting to look at the 7-gigahertz band, the X-band, for doing and performing our spectrum backhaul, as well as using 7-8 gigahertz around the lunar surface to support the Artemis missions. So not only on the lunar environment, but again bringing that data back from the lunar environment to earth. And there's a lot of competing interests in the 7-8-gigahertz band, as we all know, today.

One of the other things, do we need more spectrum? I said yes, but then the other side of that answer is no. There are areas where we can leverage on existing allocations for space use, whether it's space research or earth exploration satellite services. Another good example of that is in the lunar environment, again. We are looking at the radio navigation satellite services that are in the S-bands to develop a navigation system, similar to GPS around the earth, around the moon. And we're looking at the 2.5ish and 5 gigahertz – to 2.5 *to* 5 gigahertz; 2.5- *and* the 5-gigahertz ranges – for that LNSS, lunar navigation satellite system.

So we are looking at leveraging existing allocations that have been, I don't want to say underutilized, but not utilized as much; transitioning NASA's dependence onto some of those allocations, while also looking at existing allocations and freeing that up for commercial use.

BRUCE JACOBS: Great. Now do you want to say anything, Reza?

REZA BIAZARAN: Sure. The short answer to your question is yes. I would also like to echo what RJ said, and that's basically putting one emphasis on the fact that we can also work towards getting more efficient use of the spectrum that we have available; so that's a given.

But before I actually give some examples of why we, NOAA, or the remote sensing community actually, does need more spectrum, I'd like to draw your attention to the fact that as technology, basically we witness advances in technology or engineering, that also pushes the frontiers of the scientific work and engineering work. For those of you that are old enough, like myself, that remember 20 years ago when we tried to mention the fact that, yes, we can have small cell operations working in the middle wave or sub-middle wave or centimeter wave, 20 years ago that was an impossibility. They said, no way on earth that's possible.

But guess how many small cell operations do we have right now across the globe that basically does exactly that? Because 20 years ago, we didn't have the concept of full dimensional MIMO type transmission and reception. But now we do. And because of that, now we can have small cell operations or microcell operations, femtocell operations in 24 gigahertz, 37 gigahertz, and even higher.

So the same goes for remote sensing application. Twenty years ago we didn't know that atmosphere is actually almost 100% transparent in frequency ranges in 243 gigahertz or 600 gigahertz and above. But now we do. Because now we know that, and the technology actually allows having receivers and sensors that can actually operate in those frequency ranges, we would like to go and take advantage of that. Because that actually adds to the depth of the climate model that we have based on a multitude of operations and assessment that we can make.

So that's another aspect I wanted to mention, that, yes, we do need–

BRUCE JACOBS: I think the good news is they're pretty high frequencies. So probably not as contentious as if you were looking for 7-8 gigahertz.

REZA BIAZARAN: Yeah, I didn't want to say 2 gigahertz or S-band because I knew already that would be frowned upon.

BRUCE JACOBS: That's fine, we want you to be candid here. So one last question. Badri mentioned optical. I think it sort of segues from what Reza just said. You go up high enough in frequency and maybe you don't have to care about NTIA or FCC. How big of a factor is that? How near term are we at being able to substitute optical for suboptical frequencies?

RJ BALANGA: I guess you're looking at me.

BRUCE JACOBS: Well, initially, yeah. Badri raised it. I won't get into quantum.

RJ BALANGA: Optical is viable technology for the future. We launched in May of this year our TBIRD. That's our terabyte demonstration system; we're using optical. And some of the results thus far have been very successful. We've been going up to close to almost a gigahertz, a gigabyte of data transfer. And that's not even open full throttle the communications network.

BRUCE JACOBS: And this is in space.

RJ BALANGA: This is in space.

BRUCE JACOBS: Is space uniquely suitable for optical?

RJ BALANGA: Yeah, and that's where I was going. Optical does have its limitations. As the optical stream comes through the atmosphere, the atmosphere really degrades and causes atmospheric attenuation to that light. The light just gets scattered.

We see optical being part of our networks in the future, but not a substitute for RF. We will still need an RF component as a complementary system to get that data from the near-earth network or the low-earth orbit down to the ground somehow. And it's got to be reliable.

But the opportunities, in different parts of the world, different parts of the US where atmosphere is fairly dry without as much water vapor in the atmosphere, there could be times where optical can reach the ground and leverage that speed. But for the most part, we will have to rely for the optical to be a complementary network to RF.

BRUCE JACOBS: Thanks.

ASHLEY VANDERLEY: I would just say, for this issue, we may have to think about where the regulatory decisions are made, which agency would be appropriate if we go to the optical. Currently, there are some coordinations that are required. So a number of ground-based telescopes, when you're trying to correct for that atmosphere, you use a laser guide star, and you do have to coordinate with airplanes, with satellites, to make sure that you're not pointing that laser at something.

So there will need to be coordination. It's easier to coordinate because it's a very small beam compared to, say, for example, at 1600 megahertz your footprint is about the third the size of the United States, so it's much harder to avoid a given area, but when you get to higher and higher frequencies, your footprint gets smaller and smaller. And so, it's possible, but then you can probably do a lot more damage with that small footprint at those higher frequencies.

So yeah, that's probably something that we should maybe start thinking about, is, what would be the appropriate agency to take that on if we start to have more and more communication. So sharing, even at the higher frequencies, above 200 gigahertz all the way up to a terahertz is much easier. I think coordination is still going to be important, especially for some of the sensitive systems.

BRUCE JACOBS: Interesting. Any other panelists want to speak to that issue?

REZA BIAZARAN: Sure, I'll go next again. I'd like to echo both Ashley and RJ. Again, let me go with one example. The observations that we make – and I'm just going to say here what I call passive sensing, satellite-based or space-based passive sensing for remote sensing purposes – the observations that we make covers multitude of frequencies across the electromagnetic spectrum. A big portion of it is radio frequency range. Whether or not that specific observation can be made as an alternative source in frequencies above radio frequency range sometimes complementary, sometimes exclusive.

In other words, for example, when we try to make an estimate of what I call ice water path and the size of the water molecule in the ice cloud in the atmosphere, the droplets, the size of the droplets range from, let's say in that specific case from ten millimeters, for example, or micrometer to 50 or something in that range, which basically means constant interactions of electromagnetic wave. With that specific matter, the frequency of the electromagnetic wave is a deciding factor. So if I want to make an accurate estimate of the size of the droplets, I am only limited to a range of frequencies that I can use.

So from that perspective, that optimum range of frequencies, if that happens to fall in the rate of frequency range, there really is no other way to make that observation, which is basically going along what Zach in the morning or Glenn also mentioned, that Mother Nature decides the frequency range.

So from that perspective, I can make or we can make complementary observations in other frequency range across the electromagnetic spectrum, but the optimum range is decided upon by the physics of that interaction, between the electromagnetic wave and the molecules or the matter.

Sometimes we do have the flexibility to actually make alternative measurements or observations – infrared, X-ray, optics or optical range, you name it. But the constraints, as engineers like to say, is basically the fact that the optimal observations sometimes can exclusively be made or have to exclusively be made in a specific frequency range because of the nature of the observation.

BRUCE JACOBS: Anything, Kathryn?

KATHRYN MARTIN: Not much to add except maybe to echo. The DoD tends to be forward-leaning in terms of new uses and new technologies. So if there are the opportunities for adding new capabilities, especially if it adds to our redundancy of what we can do, then, yes, DoD is definitely open to it. And I think the regulatory questions are interesting and we'll just have to be–

BRUCE JACOBS: Yeah, I need to learn more about that. It's not a free card.

Well, I think it's time to wrap up. And I really want to thank the panelists. I want to thank the audience who've stuck with us, and the panelists. I learned something at this session, and it was great to have these experts explain what their agencies do and what some of the issues are that they're dealing with. So let's give them a hand. [applause]

CHARLES COOPER: Okay, I think we're at the end. This is starting to feel like one of those World Radio Conference meetings [laughter] that go all day and all night. So let me wrap it up in pretty short order here. We heard quite a few themes today during all the panels and the keynotes. I think number one, it's helping us inform as we are continuing to develop a national spectrum strategy. A lot of good ideas, especially as it relates to the Aspen report last week that will be informing that.

Reiterating the importance of the coordination, both interagency and among the Executive Branch, but also between the NTIA and FCC. Another important theme there.

And then also the importance of the adjacent channel issues. We've seen this pop up in a proceedings recently and I suspect it's going to be continuing. So being able to focus in on that, making sure that we capture the equities and the protection requirements will be very important.

So thank you to all the audience members for coming today. It's been a delight to see everyone. Thank you for everyone out on the internet as well, on the webcast who've been able to view it. Appreciate all the keynote speakers, all the panelists as well.

And also from my staff, I'd like to highlight three individuals that really made this pop today: John Alden, Eric Rosenberg and Antonio Richardson. Really appreciate their efforts today. [applause]

That concludes our Fifth Annual Spectrum Symposium. Have a great evening, everyone.

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