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Transcript

2022 Spectrum Policy Initiative Conference

Resolving Interference Conflicts Among "Highest and Best" Uses of the Radio Spectrum

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Day One Keynote

https://www.youtube.com/watch?v=ototyO1e2NQ&list=PLTAvIPZGMUXPndAsSb8280szXsRO0E_HU&index=1

[00:00:00.84] KEITH: So right now, it is my pleasure to introduce today's keynote speaker, Austin Bonner, the Assistant Director of Spectrum & Telecom Policy at the White House Office of Science and Technology Policy. Welcome.

[00:00:13.68] AUSTIN BONNER: Thank you.

[00:00:14.46] [APPLAUSE]

[00:00:19.18] If you see me scribbling notes, it's because I violated the first Weiser rule. I'm going to try to work on the fly here. Well, thank you, Keith, for that kind introduction. And thank you to all of you for welcoming me here this morning. Throughout my career, I've had the opportunity to work with many of the excellent telecom professionals who have come out of the University of Colorado's programs, including many talented interns who served with me at the FCC and in Commissioner Stark's office.

[00:00:44.78] So I'm really excited to finally see where the magic happens. And I'm really looking forward to spending the day with you today. So thanks for having me. Because we all care enough about these issues to be here today, I'm going to start from the shared assumption that getting Spectrum Policy right is something that we can all agree is essential.

[00:01:03.26] For those of us who spend a lot of time thinking about this unseen but critical resource, it's not difficult to explain that practically everything that President Biden has laid out for our country is his vision has, somewhere down at the bottom of the line, a Spectrum-dependent aspect. We want lower costs for American families.

[00:01:20.67] We want equity for low income people who are more likely to rely on their smartphones to get online. We want telemedicine that meets people where they are. We want cutting-edge research to fight climate change and advanced forecasting to protect Americans during severe weather. And we want national defense systems that are ready when we need them. All of these priorities and many, many more require Spectrum resources.

[00:01:44.64] And with so many uses competing for that scarce public resource, resolving conflicts is just part of the policy process. Today, I hope to convince you that the fact that we're having Spectrum conflicts is frustrating as some of them may be, is not itself a sign that something is wrong. It's how we manage them that matters.

[00:02:02.19] And then I'm going to suggest some steps that we can take to get better at handling Spectrum conflicts efficiently and in ways

that create the best outcomes for the American people. But before I dive into that, because I know we've got some students in the audience, I want to start by saying a few words about the White House Office of Science and Technology Policy, and how we're involved in Spectrum issues, and maybe convince some of you to come talk to me between sessions today about what a great place OSTP is to work as a student.

[00:02:29.82] In 1976, Congress established OSTP in recognition of the need to coordinate federal science and technology policy and to provide the president with the best possible guidance in those areas. Nearly 50 years later, OSTP continues to work to maximize the benefits of science and technology policy, to advance health, prosperity, security, environmental quality, and justice for all Americans.

[00:02:54.84] To accomplish that mission, OSTP provides advice to the president and the rest of the Executive Office of the President on science and technology matters. We steward the creation of bold visions, unified strategies, clear plans, wise policies, and effective, equitable programs for science and technology, working with departments and agencies across the federal government and with Congress.

[00:03:16.17] We engage with external partners. Many of you have been part of that engagement already, including industry, academia, philanthropic organizations, civil society, state, local, and tribal governments, territorial governments, and other nations. And we work to ensure inclusion and equity and integrity in all aspects of science and technology policy.

[00:03:37.68] Those aspects cover a wide range of domains. Coming from the FCC, I'd gotten used to spending my days surrounded by people who were laser-focused on telecom. The kind of people who casually speak in code to each other about things like MFUS At OSTP, my colleagues are military scientists, medical doctors, engineers, and many other kinds of experts.

[00:03:57.90] And here I'm going to take a personal aside for a minute to say that-- it will surprise you not at all that when you work at the White House, people want you to talk to them in advance about what you're going to say at these kinds of events. And when I was talking to our comms people, I had written in like don't make me spell out what U in FUS stands for. I promise it's funny if you say it out loud properly in violation of the Weiser rule.

[00:04:22.50] But then yesterday, I got really worried that maybe I'd made up the pronunciation of it out loud, that only I was saying MFUS And so I've been texting with my former colleague, Bill Davenport, who's worked on wireless for a long time to see if we could, in writing, agree that this acronym was funny when settle out. So thank you for those of you who laughed. Bill reminds me that like, so many FCC

Chairman, you get to the podium and you realize you're not actually a comedian.

[00:04:48.29] [LAUGHTER]

[00:04:51.21] So back to the script here. Even in the Office of the Chief Technology Officer where I work, what we call the tech team, we're covering a huge swath of subject matter from AI and digital assets to data science, the future of aviation. Those are really interesting colleagues. They work on things that I often find very scary, but really talented folks, a bunch of different subject matters.

[00:05:16.83] We are united on the tech team by the goal of making sure the government has the tech capacity to effectively deliver its programs and services, policies informed by tech expertise, that we're in the rooms where tech expertise is really needed, and then America continues to lead the world in values-driven technological research and innovation.

[00:05:38.04] So how does that translate into Spectrum & Telecom Policy? Here I'm going to say a little bit about what I do, but with a certain amount of trepidation knowing that there are people in this room who have had my job, and with a little bit of the feeling like, maybe they're going to come up with something I'm supposed to be doing that's not on this list.

[00:05:54.93] I spend most of my days engaged in policy development with our partners across the agencies. Particularly in NTIA, I spend a lot of time with my colleagues on the National Economic Council and the National Security Council staffs. There are lots of folks in those organizations who share OSTP's commitment to wireless issues.

[00:06:12.69] I think a lot of you know Tim Wu who I work with a lot. There's a great team in the National Security Council, Steve Kelley and Jonah Hill who have been great partners on these issues, and who I hope-- if you haven't gotten to know, you'll consider us a team that's available to you.

[00:06:28.84] I coordinate with the FCC on Spectrum and wireless matters always in a way that's respectful of their independence. They got that pretty fully drilled into me while working at the commission. I work with the Office of Management Budget to help formulate recommendations on budget issues that impact wireless policy.

[00:06:47.02] I provide technical assistance on Spectrum legislation and a variety of other documents, including those that our colleagues at the State departments are using in their diplomacy. There's been a lot of that in the last few weeks, and I think that's going to continue to be a theme. And I spend a lot of time meeting with stakeholders, folks in industry, academia, public interest groups. I'm seeing a lot of you who've been in lately. It's great to have access to so many smart people

who are willing to give their input and assistance, and deciding how to make our big ideas work in the real world.

[00:07:19.78] I also want to mention, because I know many of you work on telecom issues that aren't Spectrum-related also in your portfolio, that I'm not alone on the telecom beat. I have a wonderful colleague, Denise Wilson, who is OSTP's Director for Internet Access. She's particularly focused on tribal and rural broadband, and she's a great point of contact if you want to talk about infrastructure implementation, public private partnerships, and broadband funding. So please consider her a resource as well.

[00:07:47.93] So with all that said, see you students if that sounds interesting to you. Let's talk. I can point you to OSTP's applicant application process. I myself was an OSTP intern quite a long time ago, and I'm confident that I would not be talking to you today without having that experience very early in my career.

[00:08:05.47] So on the substance. Before turning how to better manage Spectrum conflicts, I want to first recognize that, however, acute some of today's hot topics in Spectrum may seem, our basic situation is just not that different from the Spectrum-use challenges of the last 100 years. In preparing to talk to you today, I learned a lot from Peter Tenhula's historical presentation at the Silicon Flatirons Roundtable earlier this year.

[00:08:31.90] I'm not going to summarize the whole thing because I really think you should read it. But I want to note here that his analysis reminds us that Spectrum Policy makers have been challenged with two, sometimes, competing roles-- preventing interference and also encouraging the larger and more effective use of Spectrum since the 1920s. We are not alone historically in the challenges that we're facing.

[00:08:52.75] The needs of existing users and new entrants have always been in some tension. And there have always been Spectrum Policy conflicts to mediate as long as there's been Spectrum Policy. That said, I think, to be sure, the stakes are high at this particular moment in our history. The Greenfield bands are mostly gone. So virtually, every Spectrum decision impacts an incumbent user.

[00:09:15.32] Consumer demand for Spectrum-dependent innovation is exploded. Cisco predicts that the Internet of Things devices will, at a total of $14.7 billion of them, account for half of all global network devices by 2023. By 2023, Americans are also expected to have an average of 13.6 devices and connections per person. I know because I have approximately 3,000 of them myself. Sure, many of you have also been interested in trying all of these new small things.

[00:09:45.51] So last month, CTIA released its latest annual survey of key wireless trends. And they found that there was two times more growth in mobile traffic in 2021 than there was in just in 2020. For a

longer term perspective, mobile data traffic in 2021 was 100 times bigger than it was in 2010 when President Obama scientists first Spectrum presidential memorandum.

[00:10:06.68] Demand for Wi-Fi is just as explosive. Globally, the number of Wi-Fi hotspots will grow fourfold in just the years between 2018 and 2013. And I would be remiss, given what my current job is, if I didn't say that consumer use is just one of those factors that's putting pressure on our Spectrum resources.

[00:10:24.95] Federal agencies are just as eager as commercial users to take advantage of wireless innovation, things that are going to really advance their missions. Spectrum's scarce resource. And I like to say that, having a lot of innovative options for using it to make people's lives better is a good problem to have. But it is a problem that we have.

[00:10:43.37] I don't want to sound pollyannish here because I know that a lot of you in this room and who are listening today spent parts of the last four years locked in seemingly intractable Spectrum disputes that took more time and maybe more resources than you had to give. But from my vantage point, there's a mindset that will help turn the temperature down and it's embedded in the title of today's event, Resolving Interference Conflicts Amongst the Highest and Best Uses of the Radio Spectrum.

[00:11:10.26] So here, I should say, my husband is a commercial real estate valuation expert. So there's a lot of highest and best use talk in our household. He actually works from a very formal definition. The Appraisal Institute, which is roughly his equivalent of the Bar Association, defines highest and best use as the reasonably probable and legal use of vacant land or improved property that is physically possible, appropriately supported, financially feasible, and that results in the highest value.

[00:11:40.55] Importantly, Sam would say, you can't just ask what's the highest and best use of a property in a vacuum. You have to ask when, because those four conditions are always changing. There was a time when four-story buildings covered Manhattan. Air conditioning and elevators changed what is physically possible, and mid rises stopped being the highest and best use of many places. That doesn't mean there is anything wrong with the decision to build them in the first place. It just means that things change, and we know that's true for us too.

[00:12:10.43] In the Spectrum policy world, receiver standards improve, broadcasters compressor signals, channel sizes change, we're facing all kinds of technological change that might change what's possible. No wireless technology stays state-of-the-art forever. When better technologies come along, we do need to look for ways to raise our efficiency standards and make the investments needed to upgrade federal systems where appropriate.

[00:12:34.07] Given the enormous benefits efficient Spectrum can offer for our economy, for American leadership and wireless services and for public safety and national security, we cannot afford not to be exacting on this point. But we shouldn't fool ourselves into thinking the work of resolving Spectrum conflicts will ever be finished. There will need for this conference maybe with different circumstances. But this question, I think, is going to be with us as long as we do this work.

[00:13:00.33] So we can't make Spectrum conflicts go away, but we can do a better job of managing them and creating a sustainable system that keeps stakeholders working through the process and not looking for detours around it. So here are a few ideas. First, we need to institutionalize a trustworthy, predictable process for managing change in Spectrum allocations for resolving Spectrum disputes.

[00:13:22.82] Over the last few months, I've met with dozens of stakeholders in the recent Spectrum proceedings. It will not surprise folks in this room that many of those stakeholders saw some gaps between the way things are supposed to work on paper and the way that they actually worked in their lives.

[00:13:36.92] During this administration, I think the FCC and NTIA have actually already made big strides in this area, particularly in their recent MOU. We often repeat the basic statement that the FCC and NTIA jointly manage the nation's Spectrum resources in the public interest. But operationalizing that cooperation is both important and not going to happen by accident.

[00:13:57.92] In particular, the MOU sets out procedures for regular coordination, and for ensuring federal considerations get to the right place at the right time in the process. That's an important signal to the department and agencies that care very much about coordination. There's more to do. All stakeholders, including federal users, need assurance that Spectrum decisions will be made in a process that provides them notice and an adequate opportunity to be heard. And all stakeholders need to operate with a high degree of transparency so that all the arguments are on the table when decisions are made.

[00:14:30.61] Second, we should be looking for opportunities to strengthen the technical capacity and laboratory resources needed to enhance Spectrum research and development. Yesterday, I got to spend the afternoon at NTIA's Table Mountain Quiet Zone with folks from the Institute for Telecommunication Sciences, a real treat. And not just because of the prairie dogs, I also saw the elk, which was a real treat.

[00:14:52.75] As many of you know, ITS is the research and Engineering Laboratory for NTIA, it also addresses other federal agencies, telecommunications, and Spectrum research needs the interagency agreements. And it engages directly with the private sector and with academia via cooperative research and development agreements.

Those relationships are incredibly important, particularly for adding capacity and depth and resources for the many agencies that need reliable Spectrum research but aren't themselves in the business of Spectrum management, and they have real world results.

[00:15:25.81] As part of our discussion yesterday, we were looking at the map that compares the original CBRS, the fast track exclusion zones and the exclusion zones as they exist today. And it really is incredible what a difference the research makes. Solid research and testing shrank those zones by 77%. That is millions of people who are going to get to benefit from CBRS who might have been excluded, and a real difference in the compelling commercial case for that service.

[00:15:54.02] Expanding capacity at places like ITS, and adding new resources can help resolve Spectrum disputes in two ways. First, it will help generate trustworthy data and highlight the work of skilled technical interpreters who can help cut through competing claims about interference. Policymakers can't always follow the science directly to an answer in every one of these disputes. Assessing risk, weighing values, will always be part of that equation. But a basic set of sheer facts is a prerequisite, I think, to working together well across the agencies and across outside stakeholders.

[00:16:26.09] And second, adding R&D capacity can better position us to take advantage of innovations in Spectrum management that create new options for policymakers like new sharing modalities. There are already talented engineers and academics doing this kind of work, and I'm hopeful that we can learn from their efforts and build on what works.

[00:16:44.72] And now, I'm going to awkwardly say that I didn't tell Nick I was going to say this about our meeting last week, which is that last week was a great visit, the White House from SpectrumX. And for those of you who haven't heard, I hope you will hear the good news from Nick about the work that they're doing since he's here today.

[00:17:01.73] But SpectrumX is a large academic hub where all radio Spectrum stakeholders can innovate, collaborate, and contribute to maximizing the public benefit that Spectrum can create. It was created with a grant from the National Science Foundation. It brings together research capabilities from a team of 41 founding researchers, staff from 27 universities, including 14 minority serving institutions.

[00:17:24.41] And as Nick and I discussed, this cross institution collaboration has the power to both spark truly pioneering research, but also to help translate those findings into policy options, the thing that I think-- for folks in my role is something that's really sorely needed, making that connection between folks who have a lot more degrees than I do on the engineering side and the steps that we need to take together.

[00:17:50.79] So third, we should support agencies work on a common technical manual or a handbook for federal users. One of the things that always stuck out at me during my time at the FCC was, I often find myself working through a docket full of technical studies that all kind of seem to talk past each other and not exactly answer the same question.

[00:18:12.63] There are always going to be parties that disagree about even the most basic study design questions. But inside the federal government, President Biden has charged us making evidence-based decisions, guided by the best available science and data-- one of his earliest memoranda to the heads of departments and agencies.

[00:18:33.77] In that document, President Biden declared that when scientific or technological information is considered in policy decisions, it should be subjected to well-established scientific processes, including peer review where feasible and possible-- sorry-- feasible and appropriate, I should quote the president correctly.

[00:18:50.40] So to advance that goal of evidence-based decision-making and scientific integrity in the area of Spectrum Policy, we should work toward a compilation of principles, guidelines, accepted technical standards, interference protection criteria, propagation models, and other characteristics that can form the basis for some shared assumption, and hopefully lead us to comparable results that we can really line up against each other.

[00:19:15.77] Fourth, we need to build the Corps of people who can do this work inside and outside the federal government. I've been lucky throughout my career as a telecom lawyer to have access to many talented Spectrum professionals who have at key moments generously explained what's really going on here.

[00:19:31.79] As much as we lawyers may wish that sometimes we could conjure up that good guidance at a moment's notice, we all think-- I think, know that kind of expertise, the kind of expertise we really need to help resolve these disputes comes at the end of a long path of education, training, and mentorship.

[00:19:49.97] Across the Biden-Harris administration, agencies that have recognized that STEM skills are the foundation for discovery and for technological innovation. Under the guidance of the National Science and Technology Council and STC, agencies are working to ensure lifelong access to high quality STEM education for Americans, and to position the United States as a global leader in STEM literacy, innovation, and employment.

[00:20:13.55] To achieve this objective, their strategy has three overarching goals-- building strong foundations for STEM literacy. Increasing Diversity, Equity, and Inclusion in STEM. And preparing the STEM workforce for the future. Those efforts are consistent with some of the excellent recommendations for developing a talent pipeline that I

know a lot of you may have seen in the Aspen Institute's recent report titled, "Toward a National Spectrum Strategy".

[00:20:38.13] Notably, Aspen emphasizes the need for educational programs for non-engineering staff who need to be fluent in the latest technological developments in Spectrum research and management. In my experience, there's an enormous demand for those kind of programs, particularly among lawyers at all levels. We can augment those efforts by attracting new talent to the United States.

[00:20:59.79] The administration also believes that one of America's greatest strengths is our ability to attract global talent, to strengthen our economy and technological competitiveness, and benefit working people and communities all across the country. In the fields of science, technology, engineering, and mathematics, fields that are critical to our prosperity, security, and health, our history is filled with examples of how America's ability to attract global talent has spurred pathbreaking innovation.

[00:21:25.74] Our commitment as a nation to welcoming new talent has long provided America with a global competitive advantage, and we must continue that effort. Earlier this year, the Department of State and Homeland Security announced new actions to advance predictability and clarity for pathways for international STEM scholars, students, researchers, and experts who are going to contribute to the innervation and job creation efforts across our country. We need these efforts to build the bench in all kinds of STEM fields.

[00:21:53.31] And I think, hopefully most of you will agree, we need all kinds of efforts to build the bench in Spectrum as a research field, as policy field, all the work that we do. Finally, we need strong values-driven leadership that can cut through institutional conflict at the highest levels and at every level.

[00:22:15.47] I don't think our recent interference disputes felt intractable because we've all just become more churlish and difficult to deal with as people. I think it can be easy, though, to dig in on one cost or one benefit when the solution we're reaching for requires balancing amongst many competitive considerations.

[00:22:34.22] Strong leaders can help keep the focus on our shared values, even when the stakes are high. Leadership can also keep parties coming back to a reliable space for negotiation, even when there will sometimes be winners and losers. And it can keep Spectrum conflicts from growing into institutional conflicts that make future Spectrum challenges even harder to address. So with all of those ideas on the table, I would love to take a few of your questions. And I'd like to start with some students. So who wants to give us the first question? Yeah.

[00:23:10.23] Hi, Austin. Thank you for being here.

[00:23:12.10] So could you wait for the microphone? I'm on the--

[00:23:16.54] Thank you so much for being here. It's great to see you again. Something that I was wondering, in your role, have you seen any great international models for resolving these disputes or other agency models for working together cooperatively to mitigate issues of interference?

[00:23:36.57] That's a great question. I am on the lookout for international models, but I feel like I'm still learning about how a lot of those procedures look. So maybe I'll put that out as a question to you all for today's discussion. If there are international models that we ought to be thinking about, let's talk about them. Please come talk to me about that.

[00:23:57.06] It is true that our situation as a country is always going to be a little different because of the way we split responsibilities between NTIA and the FCC. I think sometimes folks, even in our own government, but definitely in other governments are a little surprised sometimes that the FCC chairwoman can't just do things because she has decided to do them. There's strength in that model. I know others are going to talk about it today on some of the panels. But I think there is still a lot that we can learn from what others are doing.

[00:24:31.26] On the agency side, NTIA is I think doing a lot of great things to rebuild some of its own internal institutions to make the spaces for collaboration and working together just work better. I know there's a lot of interest in giving new energy to PPSG, the Policy and Plan Steering Group.

[00:24:54.81] I also really like what some of the individual agencies are doing where they're trying to, more proactively, reach out to industry and have those relationships earlier on in the process so they're not surprised. Frankly, a lot of them have really long term relationships with their own vendors. And so working with them on these issues, at an early stage in the process, can be really helpful. Thanks.

[00:25:18.87] Thank you so much.

[00:25:20.14] Other students? OK, other people who are not students. Lifelong learners.

[00:25:40.78] Richard Bennett, high tech forum. One of the issues that really was especially galling about the recent conflict between 5G mid-band and aviation is the fact that so many of the stakeholders really didn't participate in the process until the very last minute. I mean, the FCC, as you know, has an extensive notice and comment process in which the issues are raised and the FCC dealt with them at a technical level, but aviation wasn't satisfied.

[00:26:17.68] But they more or less remained silent until we got to the rollout date. And then suddenly, it was-- the sky was falling. Is there some way to make these agencies more cooperative? Or is that just a symptom of the brain drain of technical talent that took place during the previous administration?

[00:26:39.09] Well, here I'm going to start by saying, I'm going to take a little bit of the Department of Justice's approach and limit my comments on any particularly live matter. But I will answer your question at a higher level about what we can do going forward. First, I should say, I think Chairwoman Rosenworcel and administrator Davidson are doing a really good job at increasing their regular communication so that agencies really should know when their equities are going to be impacted by something that's coming up at the FCC.

[00:27:16.52] I think recognizing that early action is the best kind in these cases matters a lot, and that waiting to get involved isn't a good strategy. I think that's an important lesson from lots of our recent conflicts, is that early engagement at a pretty technical level is really important. I will say I think there's room for agency leadership to send that message too that, we as a federal effort, attempting to speak with one voice for the federal government, do our best when we have all engaged early in the process, and creating that expectation.

[00:27:59.13] And you're right, making sure people have the resources to do that engagement is really important. That's part of why I think I spent a little bit of time today focusing on building that bench, because I would love to see things like programs that send Spectrum managers as liaisons, that share technical expertise across the agencies. But I also recognize that those folks are in really short supply, and that it's hard to take people away from their day job to get involved in those kinds of efforts. Others?

[00:28:38.96] Dan Licbar, nice to have you here today. Thank you for being here. Long and the short of it, your comment earlier in your presentation talked about the highest and best use in the context of real estate. Just a general question, hopefully a softball. Over time, financial considerations in the industry and around the world really do drive Spectrum use. How would you integrate that money component into policy if you're really interested in evidence-based policymaking? That's a tough thing to do dynamically over time. I love your comments. Thank you.

[00:29:28.13] Well, that's a really important issue. And I'm glad you raised it. One thing that's been a little different for me, coming from the Federal Communications Commission into the government, is being a person who spends time with OMB now where they remind you that the ideas you've raised costs money, is a very important part of thinking about things like even the discussion we're all having about receiver standards. There's price tag associated with every one of those upgrades.

[00:29:55.91] One thing I think we can do better is making sure that we're not just capturing financial considerations or economic considerations that are really easy to measure, and that we do a better job at getting to the ones that are hard to measure. Some of you may have watched the Senate Commerce Committee right before the break, had a long Spectrum hearing. And they had an expert on talking about the challenges of valuing unlicensed use. And that really is hard. But I that thing is really important for us to get good at.

[00:30:31.14] I have the sense that many of you in this room are much better at CBO scoring talk about Spectrum than I am. I'm working toward understanding fully how that works, and it's important dynamic in Congress. But we also, I think, need to realize we have a lot of other economic considerations that are just hard to score and they're hard to quantify. But we have to do it. Is that enough of an answer? I think, Keith, you should tell me if we don't. But maybe we have time for one more.

[00:31:05.30] Yes, one more.

[00:31:06.65] OK, anybody else? David.

[00:31:14.85] Hey, thanks. When we talk about-- I know that this is all about the interference of dispute resolution. But when we talk about the MOU, people tend to focus on the high profile interference issues. I was wondering if any work is being done. Federal commercial use doesn't always have to be at odds with each other. And I think that commercial entities can also work with federal agencies. And I was just wondering, is there any work being done to work on those processes and think about ways that we can closely integrate commercial operators along with the federal agencies?

[00:31:49.95] Absolutely. I think tighter, more efficient, more intense sharing is going to be a big part of our future. Helping the agencies see that's both safe and valuable for them is really important. I actually think-- I mean, this is something we spend a lot of time talking about yesterday when I was up on Table Mountain, is that there are things that we can do to demonstrate better, that sharing is safe and working, and can be done in a collaborative way.

[00:32:24.28] All that said, I think the point that I made about transparency is really central to that. That to do our very best work at getting the most out of those arrangements, we really have to have all our cards on the table at the beginning of the conversation. I think that's it. Keith is gesturing to me Thank you all. This was great.

Root Causes of Interference Conflicts

https://www.youtube.com/watch?v=A3rgZgzXaB0&list=PLTAvIPZGMUXPndAsSb8280szXsRO0E_HU&index=2

[00:00:00.00] [INTERPOSING VOICES]

[00:00:01.26] KEITH: OK, we're ready to go here. So now we're onto the panel portion of our conference. And our first panel, the moderator is David Redl, who is former Assistant Secretary of Commerce for Communications and Information and former NTIA administrator. And I worked for him for several years.

[00:00:19.85] [LAUGHTER]

[00:00:21.75] Over to you, David. Thank you.

[00:00:22.63] DAVID REDL: Thanks, Keith. In the spirit of keeping the introductions to a minimum and having people look up people's rather extensive bios, since everyone on this panel is fairly well traveled in spectrum circles, I will be very brief with my introductions. First up, we have Jennifer Warren, who's vice president in technology-- actually, I think this is wrong. This is your old one-- vice president, civil and regulatory, at Lockheed Martin. How dare I have the wrong old title. At Lockheed Martin Corporation's government affairs group.

[00:00:49.92] She also sits on the CSMAC, which is the Commerce Spectrum Management Advisory Committee, since I'm not allowed to use acronyms without defining them, per Phil. And in her role there, she does spectrum, unmanned aerial systems, commercial space and launch, ocean minerals, and a host of other issues related to their civil and regulatory matters. Tom Power is the senior vice president and general counsel of CTIA, role he has held since 2015. I would define CTIA, except I'm pretty sure, now, it's an orphaned acronym and doesn't actually stand for anything.

[00:01:20.07] JENNIFER WARREN: We say that all the time.

[00:01:20.85] [LAUGHTER]

[00:01:24.12] DAVID REDL: I tossed that one up real high for you.

[00:01:25.92] JENNIFER WARREN: I'm sorry, Tom.

[00:01:26.81] [LAUGHTER]

[00:01:28.59] TOM POWER: Good. That was good.

[00:01:29.99] [LAUGHTER]

[00:01:30.80] [INTERPOSING VOICES]

[00:01:31.38] DAVID REDL: You left me hanging.

[00:01:31.68] JENNIFER WARREN: That was just a joke.

[00:01:33.11] DAVID REDL: This'll be a fun panel.

[00:01:33.48] [LAUGHTER]

[00:01:35.51] Tom's the SVP and general counsel at CTIA. Greg Guice is at Public Knowledge. Public knowledge, for those that aren't aware, is a civil society group in Washington that looks out for the public interest in a host of areas, including spectrum policy. And Dr. Jordan Gerth, from the University of Wisconsin, who holds not one, not two, but three degrees from the same university, which is impressive in its own right, is a physical scientist and leveraged observations lead at the NOAA National Weather Service Office of Observations, among his many other achievements.

[00:02:04.68] So having given a sort of headline of who we have here, I'd like to start by picking up on one of the threads that Austin had as part of her speech, which is that one of the things we need to do as a group that works on spectrum policy is find ways to make sure we have a standard set of definitions. And coming into a conference that talks about the highest and best use, and talks about efficiency, and talks about harmful interference, I wanted to start by asking the group, given your particular perch in the spectrum space, what do you consider harmful interference when you're looking at new uses? And Jordan, I'm going to start with you, because it's always good to put a professor on the spot.

[00:02:43.30] JORDAN GERTH: All right. Well, thank you, and nice to see many of you for the first time. Look forward to interacting throughout this next day and a half here. So I'll give a provocative answer to this. And then I'll walk it back a little bit. But from the perspective of meteorologists and passive microwave remote sensing, we are just listening to the atmosphere.

[00:03:08.23] So some members of our community feel that all interference is harmful. Because there is no easy way for many of our instruments that are deployed currently to determine what is coming from a terrestrial source and what is being produced by the atmosphere.

[00:03:33.06] Now, it gets much more complicated than that, because the use of microwave remote sensing is quite broad. We many different bands that we use. And the challenge becomes, what is really making the most significant impact in the weather forecast? Our incentive of spectrum use isn't necessarily profit driven. It's by making the best weather forecast possible, and the best weather forecast possible requires the best, highest quality observations.

[00:04:06.56] And any bit of interference with that introduction of a terrestrial source would lessen the quality of those observations. So it's quite the challenging problem for us. And the other thing I'll mention

about this is, when we talk about weather observations, weather is global impacts are local.

[00:04:31.25] So we can talk about spectrum policy in the United States, but that may be making the weather forecast better for Europe. Because weather is moving usually from West to East. In some cases and hurricanes, it moves from East to West in the tropics.

[00:04:49.04] So whatever we do, as a leader, we have to make sure that there's a consensus internationally along that. Because interference in one part of the world is nearly as harmful as interference in large segments of the world. So I'll start with that, and then we'll follow up.

[00:05:10.97] DAVID REDL: Great. Greg, you usually work with the unlicensed community, which is coming from a completely different perspective.

[00:05:16.19] GREG GUICE: Right. Is there harmful interference? Right? Yeah, I mean, look unlicensed is generally designed to accept all interference and to operate in a way that they account for that and try to adapt around it. And I think that's an important underpinning, but I think generally, to me, harmful interference is a degradation of service that doesn't meet the expectation of the licensed user. Right? So that's the way courts look at it. That's, I think, the way the FCC kind of looks at it, and that's sort of the baseline. Now, I would say, in addition to that, not all harmful interference is actionable harmful interference. Right?

[00:05:48.82] So even the DC Circuit has said that licensees can expect interference, for sure, and all spectrum gets interference. But they should also expect that there will be harmful interference on which they cannot expect to be compensated. And so understanding that environment, I think, is important, particularly as we move forward, where we are intensifying the use and packing folks really close together. So I think that's about-- that's what I would say on harmful interference.

[00:06:16.51] DAVID REDL: Tom, you obviously represent licensed commercial wireless users who are typically the ones who are coming into a band and being either displacing someone or being made adjacent to an existing user. So how is it that you all look at this question when you're looking at it?

[00:06:31.61] [BUZZING]

[00:06:32.89] I'm being buzzed off the stage.

[00:06:34.65] TOM POWER: Harmful interference.

[00:06:34.72] [LAUGHTER]

[00:06:37.36] It's actually you're asking the wrong people. There's only one person who knows the answer to that question.

[00:06:41.93] DAVID REDL: This ought to be good.

[00:06:42.55] TOM POWER: It's Julie Knapp.

[00:06:43.42] DAVID REDL: That's true.

[00:06:44.44] TOM POWER: He still won't tell us.

[00:06:45.66] DAVID REDL: We can all agree on that.

[00:06:47.08] TOM POWER: I thought, when he retired, he would-- no. We've never answered this question, because it is so case specific. Right? It's, what, who are you protecting? Who is claiming interference? And we heard-- it just depends on the use case you're up against. And I think that's why it's a recurring question that there's no-- well, the Supreme Court justice who was asked about pornography and said, I know it when I see it.

[00:07:11.28] DAVID REDL: Potter Steward.

[00:07:12.01] TOM POWER: I think-- thank you, Professor.

[00:07:14.59] DAVID REDL: Went to law school. Come on.

[00:07:15.46] [LAUGHTER]

[00:07:18.64] TOM POWER: So yeah, I don't think there's any great answer to it. We just have to solve these one at a time.

[00:07:23.74] DAVID REDL: Jennifer, your company deploys both very high powered systems and relatively low power systems. So you must have a unique way of looking at things as well.

[00:07:34.43] JENNIFER WARREN: Well, I'm going to surprise everybody and say, I kind of agree with Tom, which is--

[00:07:37.33] [LAUGHTER]

[00:07:38.50] It is very--

[00:07:39.48] DAVID REDL: Then I can leave now.

[00:07:40.69] [LAUGHTER]

[00:07:42.48] JENNIFER WARREN: But it is very use case specific. Right? I mean, basically it's, what impairs the effectiveness of the equipment to deliver on the mission to which it contributes? And that can be a low power, high power, mid power, very different from a radar to a satellite or a station to a certain type of sensor. And again, I say, radar, as if there's one radar. Right? I think many know we're talking about dozens of different purposes that radars can serve.

[00:08:09.68] And so they all have different sensitivities. And what level of impairment that they can have into their data that they then deliver to a larger system is pretty important from a national security, weather

prediction, modeling-- sorry to talk weather for a second. So again, I think it's very use case specific, and it's very much-- one of the things that wasn't mentioned in all the things, efficiency, and highest and best use is effectiveness.

[00:08:40.76] And that's really important element as well. That's one of those intangibles, perhaps, that Austin was talking about, but the effectiveness of the equipment, of the mission, for which that equipment is deployed is not just about efficiency. Because efficiency and harmful interference, there is no one size fits all. It varies by technology and purpose.

[00:09:02.15] DAVID REDL: Well, it tees up sort of one of the questions that we had all discussed ahead of time that we really wanted to discuss, which is risk tolerance and how you look at risk tolerance as a function of making new spectrum available. Jordan, you hit on the fact that, in EESS, the Earth Exploration Satellite Services, that any interference really fundamentally changes your predictions.

[00:09:23.48] Jennifer, I think you're hinting at sort of the challenge when you have a system that is necessary for national security, where the definition of effectiveness is we didn't get blown up. So how do you-- as you look at these things, how do you square the need for us to find more ways to make spectrum available for the public with the fact that some of these systems just are not going to be able to be degraded at all? And Tom, I'm happy to let you take the first lead on that, since you guys are usually the ones coming in.

[00:09:55.15] TOM POWER: That's sort of the flip side of your first question I think.

[00:09:57.14] DAVID REDL: It is. It's the inverse, which is why I'm giving you a second bite, because you punted on the first one.

[00:10:00.86] [LAUGHTER]

[00:10:04.16] TOM POWER: Well, here I go again, because I think it's the same answer. It's just so case specific. I think one of the challenges we see, especially when we talk about government uses, is the difference between the private sector and the government when it comes to incentives, efficiencies, investment, return on investment. Wireless companies have an opportunity cost if they are investing unwisely. The government just is a completely different model.

[00:10:32.98] And if DOD or any other agency is looking to protect their interest, it's one thing if they are advancing their technologies the way we're advancing ours. But so often, we see the case, whether it's DOD systems or other technologies and other verticals, where because it's the government, because they have a hard time getting appropriations for a whole separate set of reasons, and don't have the same incentives for efficiencies that the private sector has.

[00:11:03.55] And I think that's one of the things we run into all the time. And that's not DOD's fault, for sure. But it is a challenge, when you look at the increases in efficiency on the private side. And I just don't think they exist to the same extent on the government side. We don't really know, but you can look at the changes in mobile data traffic over the last-- Austin was citing some of our numbers.

[00:11:28.69] It's just continuing to skyrocket, and it's going to keep going up that way. So we keep investing, $35 billion in CapEx last year alone. And that's going to continue, and densification of networks and all that stuff. And then you look at the government side, and they just don't have the same ability to do that. But it means it holds back the efficiency of their systems, and then it causes these challenges, when we are trying to move in, as you say.

[00:11:56.89] DAVID REDL: Is there something to be said, knowing that there's going to be these challenges as you put new and higher powered terrestrial systems next to existing government users to be reconsidering the old concept of neighborhooding? This was the old concept that everyone like to throw out, that we're going to have a satellite neighborhood, where it's lower power. We're going to have a terrestrial neighborhood, where it's higher power. Is that an idea we should revisit? Or has technology overtaken that conversation?

[00:12:22.61] JENNIFER WARREN: So I just, I look up, and I see Paul Kolodzy in the audience, because he did try to father that idea 15 years ago, I think. 20 years ago. We may be-- we may have missed the window for that. The retrofitting and the relocation angle of that, I think, would be well outside the bounds of reality. But had we been much earlier in the process, I think Paul's idea was a great idea. But I want to go back to the efficiency if I could. Can I take us back there?

[00:12:56.71] DAVID REDL: Of course.

[00:12:58.42] JENNIFER WARREN: And compare it. I'm very glad the government doesn't have the same efficiency standard, in some ways, because government and the industry that's doing the R&D and developing the technologies to replace existing systems across government agencies. We do the R&D. We do independent IRAD as we call it. There's also CRADA, et cetera. And don't ask me what CRADA stands for.

[00:13:23.65] DAVID REDL: Cooperative Research and Development Agreement.

[00:13:25.27] JENNIFER WARREN: Thank you. Some of these acronyms you get too deep into. But they don't deploy systems before they're technologically mature. That's not the same. We all know the software upgrades, the bugs, the this, the that. They don't want to be replacing systems that aren't at a technology readiness level of a 9, an 8, unless it's in [? theater ?] for a particular purpose that they need to respond to.

[00:13:48.23] So there's a very different metric of efficiency for a commercial wireless going from 3G to 4G or just the next handset to changing out a missile defense warning system. Right? To use the most extreme. But I just wanted to put that out there, because I think, when we talk about efficiency, we fail to distinguish and differentiate.

[00:14:11.68] GREG GUICE: I would just add I think that Tom makes a good point. Look, the appropriators have to appropriate for government agencies to move. And the only way that they feel-- I would say, that congressional appropriators feel comfortable appropriating is that they know that their investment is in a space where it will last. Right? So it gets back, I think, to a core question is, what is our national spectrum policy? So if agencies are looking and there's a new flavor of like, this is the spectrum we want and we want it within seven years, appropriators think on a much different timeline. Right?

[00:14:48.88] Their timeline is a long term, and they're trying to figure out what to invest in. So I think that has to be recognized as one of the hang ups to trying to do these sorts of things. But that said, I think, on the neighborhooding concept, I think technology has sort of maybe overtaken that. We have found ways that we can use sensing capabilities. We can use database management to sort of allow folks to exist in neighborhoods more close to each other, where maybe they couldn't have before. And that might be the better effort.

[00:15:19.58] JORDAN GERTH: I would just note one thing weather satellite missions particularly launches-- our design lifetime is our planning stage sometimes takes five to seven years. The design lifetime of that satellite can take seven years and sometimes lasts even longer. We have satellite systems that are sensing in the paths of microwave now that were launched in the late '90s.

[00:15:44.28] We're still using those. So insofar that we might be able to evolve the receivers and the technology that's on weather satellites to work around some of these sharing issues, that's maybe a possibility. But it is going to take us a lot longer time than the time frames for some of these sharing arrangements that are proposed.

[00:16:10.60] DAVID REDL: Well, it leads to another great-- to bring up another topic that's been raised along this time, the Congressional Budget Office, which is obviously playing a major part in how Congress looks at this, only looks 10 years out. So you've got satellite missions that are in the tens of years. You've got CBO looking at 10 years, and you've got the wireless industry iterating multiple times in a decade.

[00:16:29.67] As we look across these different challenges, you raise the receiver question. Is it time for us to be looking at not just how we look at transmitters but how we look at receivers over the course of a longer time span, understanding that some of them will not be able to be changed out in a relatively timely or economic manner?

[00:16:52.18] GREG GUICE: That is a question that the FCC has teed up, as we all know. Absolutely, it's time to start thinking about that, and Public Knowledge along with OTI has put a proposal on the record to say, hey, maybe we should think of this not so much as like a receiver standard standard, where we look at every receiver and try to figure this out. But think of it as a FCC sort of saying, we'll adopt a standard receiver standard. Right?

[00:17:19.06] And so we'll think about it as, what are the types of receivers that we're going to try to protect? And what are the ones that were not? And tee that up at the beginning of any NPRM, so that, basically, you take a census of what's out there. So you understand what NOAA and others might have, and you look at, what's the lifeline of that equipment? What are the upgrade potentials? How do you balance those costs? And you sort of build that record. And then you talk about like, OK, under this sort of new spectrum band, these are what we will protect, and these are the folks that won't have a cause of action.

[00:17:50.53] And you move forward down that path, and you sort manage those expectations. It also has the benefit of, very early in the process, of getting equipment manufacturers and licensees that are incumbent in a band to sort of put their cards on the table, so that we address the issue of people-- I think Austin got a question from somebody coming very late in the process to the table to say, hey, it's not going to work for us. So you try to incentivize them to step forward early, so that you can manage around that.

[00:18:21.75] JENNIFER WARREN: Only because Greg brought it up, I do think there's a misperception about what early in the process is. I think, when the FCC process is live and it's 2018, that's not late in the process to be bringing up these issues. And as a friend of mine, we were just discussing before this panel, there's a difference between bringing it up politically and bringing it up technically. Technically, it was brought up in the proceeding.

[00:18:49.63] GREG GUICE: Yep.

[00:18:50.75] JENNIFER WARREN: It wasn't resolved technically in the proceeding. It was punted.

[00:18:54.50] GREG GUICE: Right.

[00:18:55.13] JENNIFER WARREN: So it was not that these issues had this un-- what is it? The Voldemort of proceedings that we don't want to talk about.

[00:19:04.16] DAVID REDL: Those that shall not be mentioned by name.

[00:19:05.81] JENNIFER WARREN: Thank you. It's not that, actually, that it was late players into the proceeding is what was visible to the public may have been late, and I mean, through the press, as opposed to into

the docket. If you go to-- if anybody actually goes to the docket and goes back to the initial proceeding, in the initial FCC, you will see comments from the Aerospace Industries Association, from Lockheed Martin, and others, who raised this issue at the very beginning.

[00:19:37.41] So I don't think it's actually a lack of visibility. I think it goes back to, how do we get everybody around the table? And I love the question that the student asked over here about, are there other models that are helpful? And while we have challenges in our model, one of the things that Ofcom does very well in the UK is it actually brings everybody around the table together.

[00:20:06.44] Now, they have a different-- they don't have that same problem with executive branch and independent agency to overcome. But you have everyone at the table talking early on. And that's a convening function, which with way we're structured, doesn't work, unfortunately, or hasn't yet worked. It works in when there's a crisis, but not as a norm.

[00:20:29.66] DAVID REDL: So I'll raise this as a provocative question. Is part of the problem we have, one of our root causes, that we no longer have final answers in spectrum policy? There's no final arbiter. The court of public opinion seems to now be the final arbiter of whether or not a spectrum decision has been made in the public interest. Is it time for us to revisit whether or not a final decision is a final decision?

[00:20:51.06] GREG GUICE: Well, I'll make a maybe controversial statement here. So I think it is a real shame that regulatees go to their regulator and get them to go to their congressional members and rough people up through that process. I would think that OMB has a role to play in tamping that down.

[00:21:17.92] That is the administration speaking. These agencies answer to the administration. But obviously, this process has become sort of very focused on-- it's not federal user spectrum oftentimes. It's regulatees of these federal agencies who use their federal agencies to gain that sort of control.

[00:21:39.09] DAVID REDL: Now, in fairness to those agencies-- and I'll take the contra side just to be fair to those federal agencies.

[00:21:44.18] GREG GUICE: Sure.

[00:21:45.36] DAVID REDL: Those federal agencies, in most cases, have their own statute they have to follow that has specific dictates that are not maximized spectrum efficiency.

[00:21:53.67] GREG GUICE: Right.

[00:21:54.09] DAVID REDL: So while I put out there, is the court of public opinion the last bastion? Should Congress be the place where some of these decisions get hashed out? Because Congress has given

contradictory spectrum instructions, safety for the FAA, and spectrum for the NTIA, to two different agencies.

[00:22:12.18] GREG GUICE: Yeah. Well, I think under the-- process that we've outlined at the FCC on this, I think you have to take that in as a factor. Right? Like, what is the safety profile of the entity that you're looking to bump up against as the incumbent? And that, obviously, has to be part of the calculation. Look, Congress does a lot of things well. I think this is one of those areas where it probably does not do well, because--

[00:22:36.43] TOM POWER: Well, they--

[00:22:37.48] GREG GUICE: And that's why we have expert agencies on safety and spectrum.

[00:22:42.70] TOM POWER: And Congress did establish NTIA as the final arbiter for the executive branch. Right? And then the FCC, of course, takes care of commercial. And we're different than other countries in that regard. But I think, by and large, some recent examples to the contrary, I think by and large, it makes sense, and it can work, and it has worked extremely well in a lot of cases.

[00:23:08.18] I think the convening is really important, and that convening, whether it's literally people in the room, which sometimes it has been, or more virtual. But that sharing of information is what's really important, but I think the idea of having the FCC and NTIA, on behalf of the executive branch, having to work it out. Trying to put another arbiter on top of that? And then if somebody disagrees with that, and if they feel empowered to go to the Hill or to the media or whatever, like that's always going to be a recipe for disaster.

[00:23:46.84] DAVID REDL: Jennifer, I'll give you one second after this. I just want to note on that-- I will add on that. Do you think it's a problem that NTIA currently has two missions, to both be the voice of the federal user and be plumbing federal bans for non-federal uses?

[00:24:03.97] TOM POWER: I think it's inevitable that-- it will vary from administration to administration-- but I think it's inevitable that NTIA has to have both of those ideas in mind. They can't-- if it's entirely about each agency's mission, then you might as well not have NTIA and have each agency sort of have the veto power.

[00:24:24.27] And you need NTIA simply to solve sharing issues between agencies who share spectrum bands all the time. So you need somebody in that role, just to be the arbiter of challenges that arise between the agencies. And then that becomes the interface to the FCC on behalf of the executive branch.

[00:24:44.79] DAVID REDL: Jennifer, thanks for being patient while I delved in a little further.

[00:24:48.78] JENNIFER WARREN: Oh, no. That was an interesting question. I was interested in the answer. But I wanted to go back to the receiver standard question, because I heard what Greg said. And I think it's a little bit more challenging than just taking into account the safety requirements that a receiver might have under another regulator's jurisdiction. So whether it's an RTCA-- OK. RTCA, Radio-- let's see. I can't remember these acronyms. I'm so sorry, folks, but it's the aviation group.

[00:25:20.46] RTCA that does the receiver standards for the FAA, for aviation safety. So that is under the FAA's jurisdiction. That's not under the FCC's jurisdiction. MIL-SPEC standards for military radars, those receivers, that's under the Department of Defense with NTIA. But I will say, is Department of Defense. These aren't things within the FCC's jurisdiction.

[00:25:46.42] So the question in my mind is, how does it second guess a receiver standards compliance and ability to perform to the objectives that the safety or mission agencies require? I'm a little conflicted on how that would really work. Does that expand the jurisdiction of the FCC to kind of second guess? I hate to use that term-- but to have a second bite at the apple of the receiver? I think there's a lot more to talk about there.

[00:26:17.28] Certainly with respect to commercial, you can-- it's all within their jurisdiction, and state and local, so public safety. But I know there are some very strong arguments about what would have receiver standards done to a lot of innovation, particularly in the GPS world, if they had been imposed without anticipation of 5G. I don't think we can anticipate constraints that will need to be put in place, because maybe, someday, someone will want to put 8G in that band. Right? What gets lost in the interim?

[00:26:48.24] And those are the opportunity costs and those types of economic opportunities that you can't quantify but you know happen when you overly constrain. And then I think Tom's right in his comment about it's worked well to date with a few big, important flare ups that affect all our lives. So yeah. OK. Other than that, how was the play, Mrs. Lincoln?

[00:27:13.56] DAVID REDL: I said upfront I was going to say, OK, let's get this out of the way, C-band Ligado 3.1. Can we move on?

[00:27:18.19] JENNIFER WARREN: No, and I'm moving on. So but I think that is just it. We are moving on, and I think this FCC and this administration is looking forward, because we're talking about spectrum sharing. And that is a very different environment, spectrum sharing, than even adjacent band. And it's pushing players that historically haven't wanted to share to look at sharing.

[00:27:41.83] Satellite's lucky. They've always had to share with themselves just by the very nature of it. But other players haven't had to do that, particularly if they're mobile in nature. So we're moving in that direction, and that forces us to look at spectrum governance very differently. Because we have stovepiped jurisdictions, with NTIA really not having authority.

[00:28:07.58] They're coordinated with, but they have no authority to limit what the FCC does. So the FCC really does have unilateral jurisdiction over all spectrum decisions. In a spectrum sharing environment, is that the right model? I don't know. Again, this has been a great FCC and a great administration discussion to date. But it's something I think that's out there, and I'd love law students to write more articles on that.

[00:28:32.11] TOM POWER: Can I just jump in on that? And maybe this is just semantics, but I don't know if what you're talking about is spectrum sharing, when you say that a wireless carrier that has 100 million subscribers using the same spectrum, or all the wireless carriers having 300 million subscribers all using the same spectrum. They're sharing the spectrum. Right?

[00:28:54.88] JENNIFER WARREN: Well, you have exclusive geographic areas. Don't you?

[00:28:58.48] TOM POWER: Yeah, but--

[00:28:58.81] JENNIFER WARREN: OK, that's what I mean. Satellite doesn't.

[00:29:01.18] [INTERPOSING VOICES]

[00:29:01.92] DAVID REDL: Therein lies-- look, this gets back to our definitional question. Right?

[00:29:04.03] JENNIFER WARREN: Right.

[00:29:04.18] DAVID REDL: Spectrum can be shared over three different domains. And when we talk about sharing, I think people-- first of all, sharing in an adjacent channel sense is very different that sharing a co-channel sense.

[00:29:12.01] JENNIFER WARREN: Exactly.

[00:29:12.46] DAVID REDL: And when you're talking co-channel, you have the time domain, the geography domain, and the frequency domain. And some industries are real good at sharing in one of those domains. Some are real good at sharing in another. Most are not good in sharing across the board. And I think that's one of the definitional challenges we've had to face is, as everybody talks about sharing, what does it actually mean?

[00:29:31.39] TOM POWER: Right.

[00:29:31.66] DAVID REDL: And I think it means-- this hearkens me back to the net neutrality debate, where you asked net neutrality advocates what it meant. And if you asked 100 people, you got 100 separate definitions. And I think with sharing, we're getting the same thing. So again, I feel like I keep pointing you, Austin, and calling you out.

[00:29:45.85] [LAUGHTER]

[00:29:46.27] But talking about a shared vocabulary and a shared way of looking at things I think is part of the challenge we're facing. And this right here was a good example that, Greg, I don't know if you want to chime in on that. I mean, obviously, sharing for unlicensed users is a totally different situation, coming in as an underlay that is not able to exercise any rights with respect to interference.

[00:30:05.17] GREG GUICE: Right. I mean, I think that is sort of it. Right? I mean, that is what unlicensed is built on. So the innovation, the technology, has to be built in that environment. And I think, as we look at other sharing technologies and other ways that we might go about sharing, that there are technological answers to some of that. Right? So and I think that is part of what the record building around it is. So maybe it is you can only share geographically. Maybe you can share based on time. So these elements don't all have to package together in one proceeding.

[00:30:34.60] It might be different ways in different bands to do the sharing. And I think that is where the FCC's role is important and where it's really incumbent upon folks to sort of state what the basis is of the technology that can be deployed. And what are the opportunities that you are going to pursue in that sharing? And so I think, that is the role of the agency to ultimately suss out. And the FCC's engineers and folks do a really-- they try to do a bang-up job. And I think they get it mostly right. Maybe they got it more right when Julie was there.

[00:31:06.10] [LAUGHTER]

[00:31:06.94] But they do definitely get [INAUDIBLE].

[00:31:09.36] JENNIFER WARREN: I don't know. Some of these go back a way.

[00:31:12.03] DAVID REDL: But Julie really does take abuse.

[00:31:13.60] GREG GUICE: All joking-- yeah. But no, I think that's the important role that the FCC can play as we look at these new sharing opportunities.

[00:31:22.51] DAVID REDL: Jordan, from your perspective, the passive services have just as much of an adjacent channel problem as they do a co-channel problem. Do you view this differently than sort of the rest of the debate we've had about active transmit users?

[00:31:38.02] JORDAN GERTH: The way that I view this is that, for us, if we were asked ultimately to share, we would probably share in time. Because our satellites are moving so quickly or gaining so quickly that we're not always just staring at one place. Now, our technology is also evolving.

[00:31:57.92] I think that one of the challenges that we have with the structure, with the NTIA, with NOAA, is we have to be better about getting the information out there. I remember one of the-- as soon as the 23.8 gigahertz water vapor sharing proposal hit the news, is there was this public discussion about what receiver NOAA was even using to sense in that band.

[00:32:29.77] And in addition to that, because of the process for NOAA to work through the NTIA, a lot of the work that NOAA did was not public. And so there wasn't-- so we lacked the information in the public fora to have an honest debate about that. And I think that getting the information out there is perhaps the best way to make sure that we're having the most direct conversation possible about receiver standards, about sharing.

[00:33:08.19] And there might be some process changes that need to be done, especially as we move into an era where companies now are maybe looking to provide Earth observations in the EESS, Earth exploration band. Because if they want to sell that and improve weather forecasts or whatever their customers demand, they have to have some confidence that they're-- for their duration of their mission, that they're not going to incur interference.

[00:33:38.44] DAVID REDL: Tom, you're usually on the other side of the information imbalance. Do you see it as as big a challenge?

[00:33:44.60] TOM POWER: Yeah. The information imbalance you mean?

[00:33:46.54] DAVID REDL: Between federal and non-federal users.

[00:33:48.31] TOM POWER: Yeah. No, I think it is a challenge. I think, when we're looking for a new spectrum bands-- and of course, I've seen this from my role today, my role at NTIA, my role at OSTP. At every turn, I've seen this, where agencies, for some very good reasons, can't always be transparent. Right?

[00:34:08.36] DAVID REDL: Right.

[00:34:08.71] TOM POWER: Especially when you think about DOD, but we sit there and look at different spectrum bands that would fit very well into the mobile inventory. And you get pushback from DOD, and sometimes, it's, no. That's the best answer you can get.

[00:34:25.90] [LAUGHTER]

[00:34:27.79] Sometimes it's a stronger answer. Right? And it's sort of a black box. We don't really know what's going on behind the curtain. And like I said, that's not-- there's reasons for that. But even when you get inside a SCIF, secure compartmentalized--

[00:34:43.39] DAVID REDL: Secure Compartmented Information Facility, yeah. Sensitive Compartmented Information Facility.

[00:34:48.25] TOM POWER: Oh, right. Even in there, the agencies are not always as forthcoming as they might be. So yeah, there is definitely an imbalance. And some of that's going to be inherent, and some of it could probably be improved.

[00:35:02.53] DAVID REDL: I'm going to pause. We're a little more than halfway through our time. I want to take a pause and maybe see if there are audience questions before we go back to these. We usually like to start with a student. So the [? Weiser ?] rule in full effect.

[00:35:28.57] JENNIFER WARREN: Wireless mics.

[00:35:29.35] DAVID REDL: There's an easy wireless mic joke here.

[00:35:31.09] [LAUGHTER]

[00:35:32.02] You have a spectrum audience, you can make that joke.

[00:35:35.10] SPEAKER: Check, check.

[00:35:36.94] AUDIENCE: Oh, there. Hi. I'm not a student, but I'm an alum of the ITP program here. And I'm also a veteran who was in a mobile ground radar unit. And I have to tell you, when I first heard about the sharing spectrum with ground radar units and how we would have a registration service in the cloud, where we would register where we were and where we were using it, I immediately thought, I don't want people to know where my unit is. Right? I don't want that out.

[00:36:06.73] I also have two daughters that are now serving, and I don't want them vulnerable to that as well. And so I think we always have to consider that aspect of things. And I really haven't heard a good answer from anybody about if a ground radar unit is using a spectrum that's being shared, how do we keep their location safe?

[00:36:34.77] I mean, and anything can be hacked these days. Right? And so if we have someone who is looking to find that information, they don't even have to geographically come here now. They can just get it off of a server somewhere from anywhere in the world. So if anybody has any good answer to that, I would love to hear that.

[00:36:55.00] DAVID REDL: Anybody want to touch on the national security and privacy dichotomy?

[00:36:59.46] TOM POWER: I haven't been real close to that issue. The only thing that I recall people talking about is ways of obfuscating that by signaling that you are in multiple locations when you're not. And so

the bad guys don't know which one is real. Of course, one challenge with that is, does that mean-- domestically, does that mean all those areas are off limits to other uses? It's not terribly efficient, but it would be one way, I think, of addressing the challenge.

[00:37:25.98] JENNIFER WARREN: So that's highlighting exactly why I'm concerned about effectiveness not being part of the discussion and just efficiency. Because whether it's frequency hopping for that obfuscation or frequency hopping for other purposes, if that's taken away in the name of efficiency, so it's narrower and narrower and narrower, what's the risks that are increased from that?

[00:37:50.43] And that's not a convenient conversation for folks to have, but that's part of the conversations that are being had. But there's a lot of R&D that is going on to try to figure out how to increase sharing capabilities without a risk increase, obviously, for the military, for the soldiers on the ground, the warfighters on the ground, or in air, or on the ships.

[00:38:20.46] But one of the things that we haven't really transitioned into is what's been done in the privacy world, which is the concept of privacy by design, which is you build it in from the beginning. And this is where I think OEMs from both the wireless industry and the various other industries, including defense, and space, aerospace and defense, can work and should work together. How do you move that forward?

[00:38:53.46] And we have challenges, because we don't have many US OEMs, but we do have O-RAN players. How can all of that work together, so that we're not constantly trying to retrofit, which is not a good situation, because you're going to have those gaps that emerge? And none of us want that result, nor the policy implications of that type of result. But there's not an appetite for that. I mean, DOD has done a great job with-- Tom kind of stopped at the last version of DOD.

[00:39:27.21] DAVID REDL: No one's going to try to define PATHSS. No one knows what that acronym stands for anymore. There's just too many Ts.

[00:39:30.33] JENNIFER WARREN: I don't even know what it started with.

[00:39:31.50] DAVID REDL: There's too many T's in it. No one knows. Yeah.

[00:39:32.97] [LAUGHTER]

[00:39:33.81] JENNIFER WARREN: S's.

[00:39:34.19] DAVID REDL: Too many S's, yeah.

[00:39:34.80] JENNIFER WARREN: It's P-A-T-H-S-S. That I can tell you. And basically, it's a process that DOD stood up, bringing wireless unlicensed and licensed and OEMs of both aerospace defense and

wireless together to look at how to share in their 3.45 to 3.55 gigahertz band. And there's a classified session and a CUI-- classified-- this is very challenging.

[00:40:01.23] [LAUGHTER]

[00:40:02.19] AUDIENCE: [INAUDIBLE] good information.

[00:40:03.15] JENNIFER WARREN: Controlled-- thank you. I'm just terrible with acronyms. I'm sorry.

[00:40:07.23] DAVID REDL: To be fair, that one's new.

[00:40:07.95] [LAUGHTER]

[00:40:09.39] JENNIFER WARREN: Yeah but--

[00:40:09.90] DAVID REDL: It's only a year and a half old. That one's new.

[00:40:11.76] JENNIFER WARREN: But anyway, and so they have a classified and a CUI session. And it's really having a different level of discussion. So Tom was right. Up until they started this PATHSS, it's very different. It's slow, but it's an important dialogue that's very awkward but I think productive. I think you guys are in the CUI. But a lot of the carriers and OEMs are in the classified, and it's good.

[00:40:36.78] DAVID REDL: Well, I got--

[00:40:37.44] GREG GUICE: I'll just maybe quickly add on the question.

[00:40:38.46] DAVID REDL: Go ahead.

[00:40:42.24] GREG GUICE: As a resistant as DOD is to these sorts of things, they've found CBRs to be very successful, and they're very comfortable with it. And they're very comfortable with the sharing concept. And in fact, in the lower three, it's something that they're looking at right now actively. And I think, so they're getting more and more comfortable with it. And the fact that they don't think it's revealing of secret information, I think, is telling, given their resistance.

[00:41:08.49] DAVID REDL: I mean, given sort of what's going on in PATHSS, do we think that we've sort of turned the corner from looking at efficiency as more users in a given band without essentially telling someone they can't operate anymore, to incorporating the other externalities, like you've discussed, Jennifer, like national security and obfuscation of location and privacy and all the other sort of things that have been sort of injected into these conversations over the last five years? Do you we've internalized that into the definition of efficiency yet?

[00:41:36.95] JENNIFER WARREN: No. I don't think that's been internalized into efficiency, and I think efficiency has been too long

identified and defined otherwise that we won't be redefining it that way. We'll have to be clear.

[00:41:49.25] TOM POWER: I would suggest a different way of defining efficiency, which is, whether it's on the private sector or the government side, it is, how do you accomplish your mission as efficiently as possible?

[00:42:00.92] JENNIFER WARREN: Sure.

[00:42:01.47] TOM POWER: And so my point I think that I-- when I first started talking about efficiency, was simply that, to take DOD, if they are operating systems that were designed and built 50 years ago, there's probably a new technology that can be just as effective, perhaps more effective. Right? It's just that it costs money.

[00:42:20.36] And one of the ways we pay for that, of course, is through spectrum auctions. But it raises-- what? About $100 billion in the last three years, but it's still a drop in the bucket compared to DOD's needs and the needs of the rest of the federal agencies. So when I say, efficiency, I'm not saying, reduce the effectiveness of your mission. I'm just saying, might there be a way that you can achieve your mission maybe even better but using a smaller spectrum footprint?

[00:42:50.96] JENNIFER WARREN: So that's really interesting, because when you look at some of the more effective missions that are being looked at, it's [? wide ?] [? B. ?] It's wide band. So the correlation of efficiency to less spectrum isn't necessarily spot on there. And that's part of the challenges and why sharing and whichever version of it we want to talk about has become more important.

[00:43:12.44] Because whether it's the aerospace industry's private sector, the wireless private sector, or all the different government users, because there's no monolith here of private sector and government. Right? We're all part of this ecosystem. Wide bandwidth is-- but for IoT-- is really the trend everywhere.

[00:43:33.23] DAVID REDL: Yep. Other audience questions?

[00:43:42.12] AUDIENCE: So I wanted to go back to the receiver standards issue. I'm wondering why it always seems as though it's the commercial users coming and saying, please improve your receivers, when it seems like the federal people should have just as big of an interest in this. The transmitters that are apparently so dangerous to the federal missions exist.

[00:44:01.19] They're out there in the world, and it might be nice to say, hey, everyone stay away, and you don't have to pay for the upgrades. But if a bad actor gets their hand on one of these transmitters, isn't that just as dangerous? And therefore, should be an interest in upgrading the receivers to preserve the integrity of the federal mission itself.

[00:44:20.75] JENNIFER WARREN: Jordan, do you want to start or?

[00:44:22.64] JORDAN GERTH: Yeah. I would say, on that question, that the challenge with government agencies is not really having the funding to do that. My experience has been, in these types of cases, that when there is a spectrum auction or some sharing arrangement, then the government agencies get money subsequently to work into that.

[00:44:45.92] The challenge is, when we're talking-- and I'm approaching this largely from space systems, satellite instruments-- so again, it just goes back to the amount of time that it takes to develop and deploy new equipment. Now, maybe in the smallsat era, there is going to be an incentive to refine the radiometer [INAUDIBLE] that we have.

[00:45:07.77] But as of right now, I don't think that exists without some really good prodding. I think, the one thing that we perhaps can do and should do with passive remote sensing instruments is equipping more with a digital back end to the extent possible, try to filter out some of the out of band or perhaps illegal in-band emissions at this time.

[00:45:39.59] And there is a satellite out there, SMAP, Soil Moisture Active Passive, that does have that capability. And during a break or something, if you're interested, I can kind of show you how that's working. But it's a long hill to climb, as I said. Again, because we aren't really dealing with a transmitter.

[00:46:01.91] We're dealing with the atmosphere, and we're dealing with an atmosphere that's emitting at very low power. And in order to capture that low power and get the observations we need, we have to design instruments for a very specific specification that may not do well as we move toward, for example, the wide band solutions that have been discussed.

[00:46:23.73] DAVID REDL: I have to admit, with your question, I find myself wondering, I don't know of-- and maybe the panel does. I can't think of an example of CMRS complaining about interference into their bands. And maybe I'm just missing one. If anybody has one off the top of their head, I think typically, since [? Part ?] 27 operates at relatively high power, if you throw out high powered radar and you throw out traditional broadcasting, it's higher power than most of the other users.

[00:46:51.59] TOM POWER: Yeah, I think there may have been some weird one-off.

[00:46:54.26] DAVID REDL: Maybe some 700 repacking stuff?

[00:46:56.15] TOM POWER: Yeah, right.

[00:46:56.45] DAVID REDL: But I can't think of anything in particular.

[00:46:57.68] TOM POWER: Yeah.

[00:46:58.42] AUDIENCE: [INAUDIBLE]

[00:47:04.23] DAVID REDL: Oh, got--

[00:47:04.81] TOM POWER: Right.

[00:47:05.19] DAVID REDL: I misunderstood.

[00:47:06.00] TOM POWER: Right. No, the devices our guys make are pretty good.

[00:47:11.98] JENNIFER WARREN: So again, it depends on the radars and the purpose for how the receiver-- what the intent of the receiver is and how wide its aperture is to receive what its intended to be able to detect. Right? I'm happy to go off line and talk about some of the different radars and the different missions. I'm not going to take up the time here, but I'd be happy to have some conversations.

[00:47:41.94] AUDIENCE: Is it on?

[00:47:43.34] JENNIFER WARREN: Yeah, you're on. Yeah, we heard you.

[00:47:45.51] AUDIENCE: I apologize. Have we moved away-- this is a great panel discussion. But have we moved away from the era where the engineers-- I'm trying to use that term collectively-- have not been at the table? And we're kind of moving into an era, where we're over lawyering?

[00:48:08.53] We do need lawyering, but we've lost the alloying effect of the engineers being a critical component in the early part of these controversies. And this goes to practice, and some of us in this room were involved. But led by Julie Knapp back in 2011, the TWG group got together. That was truly scientific.

[00:48:36.44] We had interests all across the spectrum resolving what the true interference position was between the terrestrial and the GPS at that time. So my question. Are we over lawyered?

[00:48:54.02] JENNIFER WARREN: Great question.

[00:48:54.29] DAVID REDL: I mean, I will say point blank, a panel of mostly lawyers is probably going to have a very different opinion.

[00:48:58.31] [LAUGHTER]

[00:49:00.83] JENNIFER WARREN: But I think it's a really important--

[00:49:02.30] DAVID REDL: It is.

[00:49:02.72] JENNIFER WARREN: It is a really important question. And the question is not whether or not we should be on this panel. But is what we're saying backed up by our engineers and driven by our engineers in our corporations, in our associations, et cetera? And I would imagine everybody's head is going to nod here.

[00:49:20.99] We're not here lawyering or doing regulatory policy for the sake of it. It's driven by the engineering remits that we have been given by our engineers, by those who are designing, developing, manufacturing, whether it's radars, satellites, Earth stations, or everybody's own area.

[00:49:43.13] TOM POWER: Austin touched on this. [INAUDIBLE] particularly at the agencies, it's a real need, and I think Julie will tell you and the folks at NTIA will tell you that those agencies-- and presumably the others too-- it's just been a hard slog recruiting folks these days. And I don't know quite what the reason is, whether we need more STEM education generally, science, tech, whatever.

[00:50:05.90] DAVID REDL: I think we're in an academic institution.

[00:50:07.25] TOM POWER: Yeah.

[00:50:07.70] [INTERPOSING VOICES]

[00:50:08.39] [LAUGHTER]

[00:50:10.31] But whether we need that more generally, or whether it's a particularly acute problem for the agencies, which my sense is, it is. But that's an area where I think beefing up expertise and relying on the expertise, to your point, is critical.

[00:50:24.47] GREG GUICE: Yeah. I think, look, these are all getting very technical, and there's not going to be just a simple answer that you can glean by looking at the statute, and then parsing the words, and applying it to what you're trying to do. I think, those are the guardrails. What happens inside the guardrails is more and more engineering. So it's a very important voice and probably a very large voice that should and must be at that table. I think Tom's right. It's the federal pay is not great for engineers.

[00:50:55.79] And so it's a challenge to get them to come into the agency. It's a great service to do for your country. That sounds like a plug for the Peace Corps or something. But yeah, I think it's important, and you do see this. As the FCC grapples in any sort of decision, it's oftentimes a fight amongst the engineers in these reports that their lawyers are submitting and then going in and backfilling with the argument. So it's important for the agencies to have their independent resources.

[00:51:27.07] JORDAN GERTH: So I'm not a lawyer. I'm a scientist, and I've approached this similar conversation as a matter of scientific integrity. Sometimes you hear about that in terms of things like controversial policy matters, like climate change and higher leaders in the government kind of limiting reports and what gets released. But it goes back to earlier comments I said about getting information out there.

[00:51:57.19] As a scientist, I want to interact with other scientists. I don't have the-- I was fortunate to have a very broad education, doing a major in political science and mathematics and atmospheric and oceanic science when I was at the University of Wisconsin. So I try to look at the whole ecosystem of all of those perspectives and work with our lawyers and policymakers, when I see something that's not scientifically defensible, to say, let's roll that back. Because I don't want to be associated with something that is pushing it.

[00:52:30.58] And I think that everybody that I work with understands that, that some of the arguments we're not going to make just because we're lawyering up and we're going to try to win this argument. So yeah, I'll go back to anything that we can do, yes, hiring within the government. Engineers that are interested in this are important.

[00:52:51.04] But anything we can do to make sure that the free flow of information from engineers and scientists that may be government funded through our academic institutions, or the government. I think SpectrumX is a great idea that may shed some light on getting information out there-- is going to really help evolve this and keep it, as these issues get more technical, in the engineering and perhaps the scientific realm.

[00:53:15.19] DAVID REDL: I'm going to exercise the moderator's prerogative for a second and say, I actually think-- I'm going to take a rather provocative position. I think we're under lawyered. Dueling engineers is the status quo now. Engineers decide that they're going to take fundamentally different premises to reach the conclusion that the industry they're working for has decided they need to reach. I think we're under lawyered.

[00:53:36.61] I think, to Austin's point, we have to have a common discussion about what the end state needs to look like, about what those premises are going into an engineering study. Engineering is a hard science, but it's a hard science based on soft assumptions at the beginning. And those assumptions are fungible. And as long as we are going to continue to have engineers who are given different sets of premises and told, go defend this as the ground truth that is infallible, I don't think we're going to get to the point where engineers are respected in the process the way they should be.

[00:54:08.01] JENNIFER WARREN: I was just going to add, I think the challenge of engineering hiring is probably exacerbated at the regulatory agencies, like the FCC and NTIA. When you look at NASA, NOAA, there's a lot-- I mean, they can, I'm sure, use more. But there's an excitement about the mission.

[00:54:26.95] So I don't want to suggest that the federal government just has this dearth of ability to recruit. There's a lot of excitement about what's happening in the federal government. Whether it's Artemis I or next generation satellite, space weather, there's just huge excitement.

So there is talent there that is coming in, thank goodness. But at the FCC, when we talk about engineering, it's typically looking at comms engineers.

[00:54:56.59] There is not-- despite Julie having been a leadership attraction for decades-- a lot of talent coming in that's really knowledgeable about these other types of systems and uses of spectrum. It's much less. There's some for space, satellite only really, and Earth station. But when you get beyond that, there is a very small if any percentage.

[00:55:24.43] DAVID REDL: I think we have time for one more question, if I'm looking at the clock-- I'm looking at Nate to see if he's going to be the hook. But I think we got one more question.

[00:55:32.59] AUDIENCE: Hi, I'm [? Stephen ?] [? Mir, ?] and I may be one of the few engineers in the room.

[00:55:36.72] [LAUGHTER]

[00:55:37.96] And I have a unique perspective of this issue of lawyering versus engineering. So in a past life, I was involved with the evolution of the 911 environment. And as an engineer and a business owner in that space, what I find when I go to DC and when we're working in the legal spaces, the engineers are summarily dismissed in the 11th hour, when the people go into the back room to have the final discussions and the trade-offs, in many, many cases.

[00:56:10.50] And the nuance-- and I had great folks, and we had great engineers. And I had great lawyers and regulatory folks. But in those discussions, in the 11th hour, the nuance often becomes very important. And it's not recognized by the non-technical folks. So my comment or my admonition for this would be you can have these great engineers and you can have the great lawyers. But you need to keep them working together through all the phases and not at some point dismiss one or the other and leave it in a vacuum.

[00:56:43.23] DAVID REDL: I mean, I think that's as good a summary of the conversation as I could have provided. So seeing as we're at the top of the hour, I'm going to take the opportunity to say, thank you to my panelists. And thank you to all of you here, and please join me in thanking them for joining us.

[00:56:54.15] [APPLAUSE]

Technical, Economic, and Regulatory Solutions to Interference Conflicts

https://www.youtube.com/watch?v=Z6NH-FIvMQw&list=PLTAvIPZGMUXPndAsSb8280szXsRO0E_HU&index=3

[00:00:00.38] KEITH: And for the moderator, I'd like to introduce Nick Laneman. He is the center director for SpectrumX, which is the National Science Foundation, Spectrum Innovation Center. And he's a professor of Electrical Engineering at Notre Dame. So, over to you Nick.

[00:00:15.23] NICK LANEMAN: Thank you, Keith. It looks like the audio is working. All right, so this is all about spectrum innovation, and I think it's pretty innovative that Silicon Flatirons irons decided to have an engineer moderate a panel. So picking up from the previous conversation, I'm really excited to be here. I've admired Silicon Flatirons for many years, and so it's great to be involved with CU Boulder more generally in the context of SpectrumX. And to be here at Silicon Flatirons in particular. So thank you all.

[00:00:45.24]

[00:00:45.42] So we've got a great panel. A great set of discussions to seed and translate into our breakout session this afternoon. Let me very quickly introduce these exceptional panelists, and it looks like they're not quite in order as they're listed in the program. So starting at my far right, is Al Gasiewski from CU Boulder. And then we have, Derek Khlopin from the NTIA. We have Jennifer Manner from EchoStar. And then last but not least, Melissa Midzor from NIST and NASCTN.

[00:01:15.81] So I did a bit of prep work for this panel, we sort of agreed and met, chatted a bit as a group to kind of converge on some questions that we want to address, and we do look forward to Q&A from the audience. I'll just go ahead and get us started off then.

[00:01:33.64] So first of all, given some of the issues that were raised, this panel is focused on trying to look ahead towards solutions, right? So I want to triple underline that word, solutions in the title of our panel, and challenge all of us to think about such solutions.

[00:01:48.72]

[00:01:48.95] So given these recurring issues and interference challenges, can any of them be solved by one of these areas of technical economic or regulatory, or is it really going to be a mix of the three? And by the way, our panel is set up in such a way that people can jump in as they like, but Derek I thought we'd maybe start with you on that question.

[00:02:11.70] DEREK KHLOPIN: Sure. Thank you, and I appreciate the opportunity to be here. It's been a great discussion so far this morning. You know, I think jumping right into that question, I have a sense we're

all going to end up saying it's a combination of all three. But again, to me an ideal world it's technical, that's how we get to the solutions but I think if we're honest about it, we really need the regulatory framework in place.

[00:02:35.91] I think the economic issue is a little trickier because I think we have spectrum users a lot of different motivations for your activity, and I think if we focus exclusively on the economic side of it we'd have some challenges there.

[00:02:51.65] I also think the question in a way is a little tricky because I don't think we're-- and we've heard this morning, we're not going to get rid of these challenges it's going to be, how are we going to address them? And how do they emerge?

[00:03:00.92] And I think there's a number of things here, one being actual cases of interference, right, we we're trying to resolve those. But I think the bigger challenge we have is the predicting interference, and not to go down a whole other thread, but on the idea of experiencing interference versus harmful interference, so those are challenges you've got to tackle as well too.

[00:03:24.79]

[00:03:24.94] But again, I think in a perfect world we have a regulatory and policy framework that allows us to address these issues as quickly as we possible, which means bringing the technical side into it. I think the economic considerations are part of it, but they kind of drive at the top. But again, if you're talking about big picture on frameworks and policies on how we solve these issues, the economics come into play but on a case by case basis. It really is about the technical work, and we need to have a framework that allows the technical experts to come together.

[00:03:58.38] NICK LANEMAN: It's not an us versus them.

[00:04:00.96] DEREK KHLOPIN: No.

[00:04:01.53] NICK LANEMAN: Lawyers versus engineers, for example.

[00:04:03.19]

[00:04:03.31] DEREK KHLOPIN: No, it's not. I think the lawyers or policymakers get the framework in place, but it's the technical folks who have to have the technical solutions. We need to get to a framework where we have a commonality of accepting some best practices or guidelines there. I know I know Austin commented on this, in a perfect world we get to where there's less disputes up front on how we do this work, and the methodologies, and the testing, and the analysis, then you can have conversations about the results. And the results may end up-- there you may have levers to pull on the policy side, which may bring in the economics, right? You may be weighing different factors,

you may want weighing societal benefits, but the baseline really should come back to the technical.

[00:04:50.19] NICK LANEMAN: Al, I know you wanted to jump in on this one.

[00:04:51.97]

[00:04:52.10] AL GASIEWSKI: So yeah, I will jump in as the third admitted engineer in the room. And I'm very happy that we have more lawyers involved because that means out of scarcity my salary goes up too. But with regard with regard to T, yeah, it's got to be all three there's no question about it, that's clear. But the E and R, the economic and the regulatory, they do also drive the technology because clearly, if you don't have economic forces in place you don't have the engineering groups available, the stable of engineers sometimes that are needed in companies to make new advancements. And regulatory matters also impact this, because when you do have regulations it does push companies and therefore their engineering staff to think about new solutions. So that's quite important.

[00:05:43.58] On the other hand, engineering developments the technology part of it, they don't just regularly happen. I think a lot of people who aren't engineers somehow think that, well you just put a fair amount of money in your budget and you keep hiring engineers, and you have a large enough number of them and that works.

[00:06:04.01] And generally speaking there's something they're missing, and that is, for engineers to do their stuff light bulbs have to go off. Light bulbs that are sometimes little Christmas light bulbs with regard to little ideas that make a piece of code finally function, all the way up to the biggest, brightest flood lights that came from people like Nyquist and Shannon for instance. Those kind of things have to happen, they don't happen in a vacuum. Their probability of happening is increased by the regulatory pressures, by the economic incentives and if those are increased, generally speaking the probability of those light bulbs going off happens more. And then, it's those light bulbs going off that become the technology solutions that I think allow us to proceed in solving these interference issues.

[00:06:58.33] NICK LANEMAN: Thanks, Al. Do you want to jump in?

[00:07:00.03] JENNIFER MANNER: So and I agree with both the previous speakers-- excuse me. But I would also say getting out in front and having the technical work done before anything's even developed is critically important. So I think we're seeing a number of situations now where there's decisions being made perhaps without that technical basis, and in terms of regulatory decisions-- I'll point to one, which is the FCC just authorized Linx, which is a satellite system that's going to be used terrestrial spectrum on their satellite but there's been little to no technical analysis of whether there'll be interference issues. The FCC

did put a number of restrictions on them, whether they're the right or the wrong restrictions we'll see.

[00:07:48.18]

[00:07:48.22] But I am a little worried that we're not moving earlier to do the technical analysis, and sometimes the regulation moves ahead. And I know there's a real jump, we want to get new technology out, we want connectivity, certainly we all support that. I work for a satellite company, believe me I care nothing more than getting everyone connected. I'd like you all to be our customer, but the fact of the matter is you have to do the technical work. So while I do think it's all three, I think both the other speakers agreed it's the technical that has to drive it.

[00:08:18.54] And there's one piece that's not here, which is the day-to-day interference. Many operators experience harmful interference, accidentally or on purpose, and have to work together to do that. And I think that's one area-- I know we're going to talk a little later about incentives, but that's one area which I do think works pretty well because there is a mutual need to have no harmful interference so people are willing to work together, and I kind of put that. I don't even know if you really need such a regulatory or economic incentive, that you kind of have that already or framework. So just some thoughts there.

[00:08:53.31] NICK LANEMAN: Go ahead.

[00:08:53.54]

[00:08:53.59] MELISSA MIDZOR: I just wanted to emphasize the, having them in the room together, and with all three you can't have just regulatory and economic, and the technical separately. We're working on evaluating the ecosystem of CBRS, and it's been very interesting to see when we have here the rules coming from the regulatory side, what you can't have the information on. The engineers and the scientists will rise to the challenge and try-- OK, what new ways can we measure this? What new ways can we get the information that we need? That understanding why those rules are in place and why they're important. So both privacy laws and mission critical, classified information weighed against, my life would be a lot easier if I could just measure that, but I understand why we can't just measure that.

[00:09:38.19] And so having all those people in the room together has really helped move the conversation forward. And also coupled with the economic is that we also on the economic side, understand the drivers of what we're trying to solve this technical problem against the regulatory limitations the economic drivers really help us hone in on what's the most important question I should be asking and solving at this particular time and junction too. So those three working together,

all three need to be at the table as we move our way over time to these issues.

[00:10:08.63] NICK LANEMAN: Yeah. I find it's really fascinating when you look at the history of spectrum regulation and management, there's been innovation, either on the technology side, or on the economic point of view, or on the regulatory side, in various stages throughout the years and it's fascinating to see the interplays among them. And so I do think that they're intimately coupled, and so that's why I like this notion of innovation maybe spectrum innovators, as opposed to lawyers or engineers as a field.

[00:10:38.12] All right, so here's a provocative one that we agreed to address. If you were ruler for a day. If you were the grand arbiter between the FCC the NTIA et cetera, what changes would you make in spectrum management to mitigate or prevent harmful interference issues from cropping up, especially the loud public ones that make the news. And I think Al wanted to take this one on first.

[00:11:01.17]

[00:11:01.37] AL GASIEWSKI: Yeah. And I'm going to change that phrase from ruler to persuader in chief, because I don't think there is such a thing as a ruler anymore. But supposing I was that individual-- You know, we are doing a lot in that area right now. We have a number of government entities in place that attempt to do exactly that.

[00:11:24.02] I think one of the things that we're missing is being able to reach out from those government entities that could help resolve these conflicts, and draw in enough people often enough from around the country, even outside the country, to help develop these mitigation methods. I see that-- now in the COVID era of course, people can work for a company and be anywhere in the globe, just by Zoom. Why can't we be doing more of that from the standpoint of engaging the engineers as well as the lawyers so to speak, to all around the country to address some of these problems as need be.

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[00:12:08.70] Some of the most successful small companies I've seen, form around projects, and the people who work on these projects are not necessarily contiguous. They're not even full time employees of the company, they come together for a particular project and when that project is over, they dissipate. It's just that the rate people are brought together in. And I think we could be doing a little bit more of that to help make these activities already being effectively managed by FCC and NTIA, more effective.

[00:12:41.84] NICK LANEMAN: Thanks, Al. Melissa.

[00:12:43.87] MELISSA MIDZOR: So if I was ruler of the day, I think one thing-- and then building on what Jennifer said earlier, is we need to

identify and fund risk reduction studies with more emphasis on the technical side. We do a good job with the initial modeling to understand where the issues are, but there's a lot that can be done on the technical side.

[00:13:03.38] One of the catch-22s is that, until we sell the spectrum there's not equipment to go test to see what's going to be causing the impact. But there are many ways where you can make proxies, and you can make reasonable assumptions on the technology to help determine what some of those potential impacts might be. And having that additional information up front, before the auctions, would help incumbents have a better understanding of the potential impact to their systems.

[00:13:33.10] For the investors and industry it would give them a better idea of the value of the frequency band that they're attempting to buy. And then of course, you always have the post auction measurements, but there's a lot we should be doing before the auctions to really help inform both sides, incumbents and investors.

[00:13:53.46] DEREK KHLOPIN: And I think it's simple, you just make NTIA the ruler. Nobody can question. No,

[00:14:01.13] AUDIENCE: For sure.

[00:14:01.92] DEREK KHLOPIN: Yeah, exactly. Yeah. Now, I mean there's a lot, a lot things, and I think some of these ideas-- and like I'll come back to what I said before-- and what Austin said I think he actually-- if we could lock everybody in the proverbial room for a week, or all stakeholders and come up with-- and I know this is a little pie in the sky. But a framework, or guideline document for particularly the technical analysis, so you'd have a set of best practices or guidelines on how you perform X study? What are the parameters that are accepted? Can you actually agree on some things?

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[00:14:34.90] And I know it's a challenge all right, because you need the input in the parameters from a lot of different parties but the modeling, the statistical analysis. The propagation, can you agree on a propagation model? Those types of things, so when these things come up you have them. And then the flip side of that being would agree that these are more or less binding in a way, right? I mean I know that's not perfect because then you get to the regulatory side and facts may change.

[00:15:02.66]

[00:15:02.84] So I mean, that would be great. It's a little theoretical, but I kind of feel like we have a lot of these activities, even something like this and where we talk about a national strategy, or you have a report but something that would be more technically based where you could

get to some level of consensus. Knowing it's not perfect, but it would at least be a baseline, I think would be great.

[00:15:23.75]

[00:15:23.85] And again, how you actually get that done is obviously a challenge, but we're not going to have a ruler for the day anyway really, so it's kind of theoretical.

[00:15:33.29] JENNIFER MANNER: Actually, I can be ruler for the day. So I just want to touch on what you did Derek, because I don't know if you live through the FCC's negotiated rulemaking process in the '90s, putting us all in the room it was-- and we only met in person then there was no Zoom, was-- and I know a couple of my colleagues were there. Was incredibly painful, and was incredibly difficult to get to solutions, and that was really just what the commercial industry, so putting in the government folks. And I'm not saying it's a bad idea and we shouldn't try, I'm just saying I'm less hopeful, so I'm not quite sure how we get there especially as politics are involved. So I would say, I would take a step back.

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[00:16:12.98] I think one of the problems we have with spectrum today is that we make a lot of our decisions-- a lot of what we end up with are studies are based to defend decisions that we've made not based on technical facts, and I blame Julie and Dale for me being so fact based, and it's something I was certainly taught at a young age.

[00:16:36.89] And so I do worry that we have certain outcomes that we want to achieve, we want to do something with C band. We want to use K band for something, and so a lot of what we end up doing is shaping-- there studies that are shaped around the results we want. And I think we need to take a step back-- we may still have a policy or a goal in mind, but I think we really have to take a step back and look at this technically, not just in band but also adjacent band. And something that I'm increasingly concerned with that Julie, I know doesn't agree with me which is aggregate interference. And we've been arguing about the-- OK you're a good then? OK.

[00:17:16.76] AUDIENCE: [INAUDIBLE].

[00:17:17.23] JENNIFER MANNER: OK. So but aggregate. But really take a look at these issues, and then also look at the use. I hate to say it there are certain uses that can be seen as important even if they're not the most economically advantage-- advantage, advantageous to the US economy, the science services, space services, other things that maybe a lot of people don't think about.

[00:17:42.35] So I think we have to take a step back, that's something I'd like to see is that we actually maybe do some work beforehand and look at it a little more neutrally, as opposed to putting out a proceeding

and making a decision and saying, OK folks this is what we're doing. And we do that a little bit with the NOI process at the FCC, but even then it's really done with pretty much a clear purpose in my mind. And I don't know how you get there, so that's where I look at my subjects to determine how to implement this. So thank you

[00:18:12.78] NICK LANEMAN: So I thought about this question a little bit and I'm going to react to, kind of real time to what I'm hearing. Maybe one thing that I would do if I were appointed ruler is set a deadline for a national spectrum strategy, and an editorial committee, and a chief author or editor of that committee who would be responsible for getting that document produced. I don't know what you all think about that.

[00:18:37.68] JENNIFER MANNER: What would that document have? What wouldn't that look like? I mean, it's very easy, I can do one paragraph national spectrum strategy or I can do a 4,000 page.

[00:18:48.50] NICK LANEMAN: Yeah, we'd have to figure out the expectations for that document, but there's a lot of talk about creating the next generation of the spectrum pipeline, right? So identifying some of these bands but being a little bit more holistic about it, the way you describe. Figuring out the respective roles of the FCC and the NTIA, as an outgrowth of their MOU. I'd liken it too-- we wrote a proposal to get the SpectrumX grant, and then our first homework assignment was to develop what they called an implementation plan and so that became a couple of page document. So if we did something along those lines. I think that would be pretty constructive.

[00:19:30.86] AL GASIEWSKI: So I would comment along those lines-- and we've had NRC committee study spectrum issues before and I was on two of those committees studying passive uses of the spectrum for Earth science, and active uses for Earth science. It seemed like the NRC might be a place to begin that study, recognizing that it's not just purely technical though, but it is very much a political, and there have to be a number of sociological issues brought in, fairness for example. And access to spectrum. Fair trade policies, that's a lot more so than what they're used to working on. But that kind of a committee it sounds like you're really leaning towards.

[00:20:10.47] NICK LANEMAN: You know, in my formative years for example, the PCAST report and the National Broadband plan, those were substantial documents that really fueled a lot of activity for the last 10 years or so. I think we could potentially create something of that ilk.

[00:20:26.40] OK. All right, so in some sense it all comes down to incentives. Spectrum allocation and management has many different stakeholders, what incentives might help prevent new issues from arising? It sounds like Melissa would like to take this one on first.

[00:20:42.77] MELISSA MIDZOR: I would. I actually would like to address two aspects of that incentive, one of them is mission based and the other one economic. A good example for a mission based one, and I have been pounding the sidewalk on this, I had 15 years formerly in electronic warfare in the DOD is I think spectrum sharing is the best thing that could have ever happened to the DOD. We need to learn how to operate in a spectrum we don't control, and what better place to try that than at home before you go overseas and try and do it for real. So I've been part of the small group in the duty helping try to push that.

[00:21:17.95] The other one is an economic one, and that I think Albin, you mentioned that earlier is fair co-existence. If we could objectively measure fair usage of a shared band, right now it's an incumbent priority. The modem is that, if you're joining, and like in Wi-Fi, or in blue, if you're joining the spectrum you have to not cause any more additional information than if the incumbent was just adding another system. But you're not really looking at what's fair across the whole band and all users, and really optimizing the spectrum usage by using the-- if I got there first I get priority modal.

[00:21:56.68] So I think having the methodology, the metrics, the method to measure what fair codes-- because codes have to agree with their coexistence is, but then you need to be able to measure it and be able to enforce it. So I think that could actually provide an incentive, because if I was a new company and I knew I would have a shake, a fair use of the spectrum and share it and not just have to figure out how I'm going to fit in, that would provide more incentive to try and to launch into these new spectrums.

[00:22:30.19] NICK LANEMAN: Thanks, Melissa. Derek.

[00:22:32.81] DEREK KHLOPIN: Incentives, it's such a tricky issue, it's one that's-- I think it could probably go back 20, 30 years, and we've been talking about this. In the big picture I think the market has a number of incentives for the commercial side, I'm not I'm not sure there are always as strong as advertised. I mean, particularly in the world if you have exclusive licensing and you have the spectrum, you know, what were your incentives to operate as efficiently there as possible? I don't know, I think there's a lot of questions there.

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[00:23:01.00] I think you're naturally incentivized to avoid causing interference, because the problem that creates and vise versa, but a little closer to home looking at the federal use side. I mean, this is something we've struggled with a long time, and there's been a lot of different proposals on there on how do you incentivize agencies? And Melissa make a great point on sharing and I think we're seeing that.

[00:23:22.53] The other larger point for federal agencies, is the federal spectrum footprint continues to shrink. It doesn't grow, right? So you know you're operating in a condensed environment, you will be going forward, there's always going to be a demand for more commercial access, so I think you have a natural incentive to try to maximize what you have. But the other part of it is-- giving you the weeds a little more, is the actual process of transitioning spectrum to the commercial side, and we're under laws now where you get reimbursed for spectrum relocations. But there's a lot of limitations on it and some of it's for good policy reasons, for example, an agency can replace its systems with comparable capability, they call it.

[00:24:07.51] Well, I think the real incentive would be if there was a better opportunity to upgrade those systems and deploy new technology, and utilize some of that-- you know, the massive economic streams coming in from spectrum auctions so that the agencies could actually do more with their spectrum. And you could have an efficiency hook in there, right, to where you can get new capabilities, new equipment, new systems but you have to demonstrate the spectrum efficiency components of that. So I think that's one sort of small piece of it that I think is something that we're thinking about a lot more.

[00:24:40.59] NICK LANEMAN: Al.

[00:24:40.72]

[00:24:40.88] AL GASIEWSKI: On the technology side regarding incentives, there is a project that we started developing under an NSF EARs program and now it's being further developed under Swift program, to develop a spectrum broker. And the broker operates kind of like a traffic cop on one of those European piazzas where everybody's trying to get through, but they don't want to ding each other's fenders so the traffic cop is up there giving directions. You kind of request you want to go in, traffic cop waves you through. The broker is doing that basically on a millisecond basis at 100 kilohertz spectral intervals, in over perhaps 10 kilometer regions regularly to people who want to access a certain chunk of what we call electro-space.

[00:25:24.02] And the broker can't issue tickets. It's not the kind of traffic cop that can write you one and take you to court, instead, it's a suggestion. You put in your request to use that electro-space and within a millisecond you get your response back, it's either go, you're clear, or no go, you're going to get dinged by somebody. And that had actually an incentive structure, because as more and more users buy into it there's more and more opportunities for the broker to come up with the proper routes, so that effectively people can get through the Piazza without bashing each other's fenders, in other words remove the potential for interference.

[00:26:04.92] And the more you buy into it, the more you get to use it in other words, by effectively being part of that. And think of it the other

way around, let's say you want to get through the Piazza with your car and you don't want to pay attention to the traffic cop, you're going to get your fenders dinged more often. So that's the whole idea of the incentive structure behind this broker.

[00:26:26.66] JENNIFER MANNER: So I kind of really like that but-- because I was thinking of this-- so I'm a little negative on incentives, I think you can't incentivize people unless you have realistic scenarios and we've seen that in a number of bands, Jennifer Warren mentioned how the satellite industry is very good at sharing because we've always had to share.

[00:26:45.80] But the problem is people were sharing with now may not be as good, and I'll give you an example of something the FCC decided to create a shared band at 27.5 to 28.35 gigahertz for the UMFUS, Austin mentioned UMFUS earlier so I'm not going to define it, or she defined it for us. Because I couldn't remember what the definition is, but I'd like to her. But UMFUS and FSS, Fixed Satellite Service largely for individually licensed service stations or gateways, and so who's coming in first is supposed to have the right for that location.

[00:27:21.56] And there's huge restrictions on how the satellite operators can operate, we can't be near highways. We can't be near a football field, stadiums of 10,000 people or more. We can't be near ports. We can't be, I'm sure we can't be near amusement parks. Anyway, there's this exhaustive list that we fought very hard. And what's ended up happening is It's been a very hard process because it's not realistic for many of the satellite operators to find a location where there's access to fiber and people to operate the gateway stations in the very strict confines that the FCC created. And so that's a situation where I think maybe a traffic cop would work better, than putting in place this unrealistic kind of geographic separation requirements that we've seen.

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[00:28:11.44] So that's why I find that this question of incentives is hard, I think getting ourselves together, self interest I think is always best. But we see a lot of people who will look for reasons, anti competitive reasons to block people from sharing, so I consider to think that you've got to start with what realistically can share and go back to the technical basis. That I think we've been talking about, which is if you don't start with a real technical understanding you're not going to get to even able to incentivize sharing.

[00:28:45.42] NICK LANEMAN: So I'll jump in and say that one thing I've observed that's been fascinating, somewhat from the outside, is this notion of spectrum relocation funds being invested for R&D through the National spectrum consortium. And so initially that was very heavily focused on, enabling legacy DOD systems to better coexist, but in recent years, there's been a growing emphasis on 5G and securing 5G.

So I see this as an interesting way in which these two ecosystems have the potential to collide and negotiate completely different ways, even within DOD, of using commercial technology and also meeting the demands of its mission.

[00:29:29.80] And I think that the best innovator for spectrum sharing could be DOD itself. Using some of these evolving technologies. Using private 5G type networks and their additional very specialized systems, it would be fascinating to see if that actually comes to fruition. I think they have plenty of incentive to take advantage of the economies of scale of these technologies, and we're seeing that, the biggest issue, of course, is the security constraint as far as I can tell.

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[00:29:58.75] So I think being innovative in the way that individual agencies and these ecosystems kind of collide might help incentivize more and higher and better use of spectrum. I don't know if any of you want to react to that.

[00:30:12.58] DEREK KHLOPIN: I think you said it well, I think that is something interesting. I think we're all watching in to some extent, participating in, and Lizzie you kind of hinted at that too with the DOD effort here with spectrum sharing. DOD is interested in a new environment and they see the world around them not just going to 5D, but the capabilities there are very different, they talk about the connected war fighter.

[00:30:35.92] So you kind of have an offensive and then a defensive approach there as well too, and it's going to be interesting. So I agree with you though, a lot of the focus around the DOD work has been looking at their legacy systems and how you coexist, but I think where they're looking at on the sort of 5G, 60 path is going to be fascinating.

[00:30:57.38] MELISSA MIDZOR: Yeah, the DOD is looking at spectrum is like a fifth element, you've got land, sea, air or space, and they're looking at spectrum as an actual, just another environment that they need to maneuver in.

[00:31:08.50] DEREK KHLOPIN: And just to get a little quick too, I mean and we're talking with DOD, but I think for a lot of different federal equities and interests you're going to see similar and this sort of coming together. And I mean, at least it gives me some optimism for this interagency collaboration on some of this. So I think-- in our role at NTIA, we really know we need to be at the forefront of bringing that all together and looking at a national approach to this, and then working with the Commission on this too. Because there's a lot of overlap between these uses, and reaching out the private sector and having these conversations.

[00:31:43.35] Because all coming together, it's not just the terrestrial stuff, it's the space stuff, and it's all really working together now in new and exciting ways.

[00:31:53.79] NICK LANEMAN: The one thing I'll maybe add to that is that in building up this Spectrum Innovation Center with NSF, the shared incentives that we heard, everyone we talked to were concerned about getting the next generation workforce. Everyone we talked to was concerned about national competitiveness. And so I think the more we focus on those economic development, the more we focus on those as shared motivations, I think we can get aligned and perhaps collaborate, and make better, and better, and better use of the spectrum.

[00:32:27.90] All right, so in cases of unavoidable harmful interference, how can the relative societal value of spectrum for various services be assessed? Does this approach have merit in resolving spectrum conflicts? It kind of gets to the financial side of what we talked about earlier. And I think Al wanted to jump in on this first.

[00:32:46.01]

[00:32:46.06] AL GASIEWSKI: Yeah. Yeah, and I think it's really hard to just say that this is a pure financial issue because then we have to somehow put a cost on environmental remote sensing observations of the planet, not just for weather but also for climate. And so we've got to look at these all from long term, or short term, or perhaps local perspectives in terms of their costs. For example right now, the cost of us not knowing that our climate is changing is quite considerable when you project this out to the future in terms of what we're going to have to be paying for the next hurricane that hits, et cetera, et cetera.

[00:33:26.29] So, and in other situations as well. I'll go back on that issue, because I'm not going to claim I'm holier than thou in saying that environmental applications are the only, and best, and highest purpose of spectrum. There are situations where spectrum should be used for other purposes for example, in areas of conflict, and we have enough of those around the globe right now. The immediate environmental needs of spectrum probably have to take a backseat to strategic uses of spectrum.

[00:33:57.92] And same thing would happen in emergency scenarios, for example. So my point is though that we have to weigh these from not only short term economic perspectives regarding the, let's say quarterly bottom line of a company and how much tax they're going to pay, but we've also got to look at this from the standpoint of the longer term costs of not having the information that certain spectrum might provide. And I think climate is the poster child for that particular application.

[00:34:30.12] NICK LANEMAN: Jennifer.

[00:34:30.36]

[00:34:30.47] JENNIFER MANNER: Yeah, I actually fully agree. And that was kind of my point early on, that we have to take a step back and really look at things before we do them and don't go in with just a plan use. If there's important spectrum uses which don't necessarily equal dollars and cents, but equal other societal benefits, you've got to take that into account and you have to look at long term implications as well. So I fully agree. I think that's very well said.

[00:34:58.02] NICK LANEMAN: Derek.

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[00:34:58.38] DEREK KHLOPIN: I mean it's-- I just really going to concur, I think that was articulated well. And I think we have a number of national priorities, and Austin mentioned that a lot of these do have spectrum implications and I think that's everything we need to try to balance, and not losing sight of the economic side, but also a lot of these, whether it's climate or-- they also contribute to the economic picture too, so they're not they're not entirely distinct. And so a lot of difficult priorities and that we need to balance as part of this.

[00:35:33.44] MELISSA MIDZOR: I think my esteemed colleagues have covered most of it. Perfect.

[00:35:36.62] NICK LANEMAN: Maybe I'll just take the opportunity to throw in-- I have had the opportunity to interact with a couple of economists along the way in building up our center at Notre Dame and this new initiative with SpectrumX. And once upon a time, there was a thought that sort of-- instead of raw market size numbers in the billions, using tools from cost benefit analysis might be helpful here. And the other is, not just the-- I'm going to probably misquote this, but Tom Hazlett is on our team for SpectrumX, and he emphasizes the marginal utility as you explore trade offs in different uses of spectrum.

[00:36:20.80] And so I think, in general getting more of not just the engineers but also the economists involved in these equations, to try to come up with models that allow for us to explore the trade offs could be helpful here. We may not get the absolute numbers, but we may be able to figure out relative numbers along the way.

[00:36:40.54] All right, so-- and in fact, one of the things I was going to mention is, at least from my perspective, issues like the radar altimeters and the filters on the front ends of those altimeters. If 40 years ago when some of those altimeters were designed someone factored in the potential cost of having to upgrade those receivers, because there's some probability that the spectrum environment would change over 10 years time frame, or 20 years time frame. Maybe that kind of thinking about the long term change of the surrounding spectrum environment could justify some initial additional expenses on the front ends of those filters.

[00:37:22.78] And that's my intent to transition into our next topic, which is that there are those that argue that setting receiver standards would solve everything here. So do you agree with that? Is that a long term solution or only a temporary fix, until other aspects of technology mature? And Melissa, maybe you could take that one up.

[00:37:45.73] MELISSA MIDZOR: I think it is-- it doesn't fix everything but it is so vital to the conversation, a large number-- especially the big spectacular issues like the radar altimeters, and [? Ligado, ?] and the-- and mention of that name, and the GPS situations receiver, it's not that the transmitting systems are going outside of what they were granted it impact the receiver system. So definitely, we need both sides of the equation, we need both transmitter and receiver considerations when we're talking about standards and when we're talking about potential impacts and an interference. To draw a little bit on what you just mentioned, if we had 10 years how do we build in that technology going ahead?

[00:38:32.90] The [? Nason ?] report, one of the things that they mentioned is because we've been fighting the GPS issue for so long the manufacturers have already baked in solutions, and they've had almost 10 years to do it. But they've baked in solutions, so that when the new systems do come online they'll be fine. It's just some of them, there's a handful of the older systems that are still issues and the DOD still has some systems that they're concerned about. But by and large, the industry has moved in that general direction on how to change their receivers in order to compensate for new neighbors to their spectrum.

[00:39:13.11] But one thing I want to point out is when-- for everyone who read the roundtable report that this is predicated on. And one of the items noted in there is that we need an agreed upon definition of harmful interference, is imperative and common terminology. And as was mentioned in the last panel on this panel, there is no one definition. I would suggest that needs to be changed too, we need a framework, an approach, to get to a common definition in a particular area that we're concerned about. I don't think we'll ever get to a common definition.

[00:39:45.62]

[00:39:45.68] And then it's hard to separate interference from technical impact, to mission impact, so all of those things need to be rolled in. How they affect each other, and how it varies versus what it was intended. So I have a long winded answer, but I don't think it fixes everything, but I think it would fix a lot to have an approach to receiver standards or a standard to get to a receiver standard in a particular area.

[00:40:12.83] NICK LANEMAN: And to clarify, are you suggesting that the FCC should set the receiver standards or just mandate that there

needs to be a receiver standard, and then have the industry come up with that standard?

[00:40:23.28] MELISSA MIDZOR: Probably the latter. Coming from NIST and coming from the standards, we don't actually issue most of the standards. Most of the standards in the United States are issued as-- it's a joint coalition between industry and federal to come up with those standards. We're very different from other nations in that area, other nations they have a body, they make the standard, and it's a government institution, and that's that. Here we took the exact opposite approach where our standards really come from industry and those joint coalitions.

[00:40:57.18] NICK LANEMAN: Derek, did you want to jump in?

[00:40:58.11]

[00:40:58.27] DEREK KHLOPIN: Yeah, just quickly. I mean, all that's right. I think receiver standards or performance requirements certainly play a role, as folks know there's an inquiry from the commission right now going on. I mean, the problem is one, that you have to define-- you can say set a receiver thrash it, but then you have to agree to what it is. And it is going to be different in different areas.

[00:41:21.28] We dug in a little bit on the federal side and realized we actually-- everyone says there's no receiver standards but that's more maybe on an FCC regulatory side to a certain extent, but we actually have quite a bit on the federal side that actually we do. There are a good amount of receiver performance requirements as part of the NTI process for managing spectrum, it's a number of areas it's adopting, typically it is adopting industry standards like TIA standards in the mobile space.

[00:41:48.28]

[00:41:48.52] And we have an effort going on right now that's actually looking at radar issues, so there is some out there, but again, it's not it's not going to be a panacea. But I think even setting that expectation that your spectrum environment may change does help.

[00:42:04.16]

[00:42:04.20] But there's really no getting away from lifecycle issues too, right? If you were a federal government system and you're going to have a system that operates for 20 years, it's a very different environment than if you're in the mobile wireless industry or on the short cycle, so. You can work toward these things, it'll take a while, and then you just have to figure out how to grandfather and roll things out, but I think there's pretty wide consensus that we need to look at the receiver issues more closely.

[00:42:33.52] NICK LANEMAN: Al.

[00:42:34.65] AL GASIEWSKI: Well, I'm always in favor of better receiver standards because it'll increase the scarcity of engineers. With that said, we do this--

[00:42:42.62]

[00:42:42.68] NICK LANEMAN: In a value.

[00:42:43.90] AL GASIEWSKI: We do this in the auto industry all the time. We do this through CAFE standards. We do this through auto emission standards, and this has changed the industry. It's changes so much that we're now within a transition to electric vehicles. So yeah, I don't see why we can't do that.

[00:43:00.16] But I don't think we should stop at receivers, because receiver is half of it for a comm system, and we have to look at, of course, the other half of it as well. How do we make better schemes for communications that may even involve multiple modalities, not just using the spectrum but perhaps using land services as well? So there are lots of what I call related technologies that could be brought in to bear along with just the receivers, but a phased in approach I think that would make a lot of sense.

[00:43:29.52] NICK LANEMAN: Anything on this one Jennifer?

[00:43:30.38]

[00:43:30.44] JENNIFER MANNER: Yeah. So I think my one addition would be really have to look at this in individual frequency bands and based on services, you can't just-- I mean receiver standards yes, they're a good thing. I mean, I'm very pro standards and I would agree entirely with Melissa, they should be standard driven by the standards bodies and not by regulators. I think we know technology's better than the government does, and I don't always think it works so well in other parts of the world.

[00:43:58.20] But I do think you've got to take a look and see what's there, and how things are operating and maybe even make certain priorities where there are more risks. I think Derek brought up a very good point about long term systems, satellite systems like ours or [? GEOS, ?] so we're up there for 15 years, equipment has to talk. So you got to look at this on a phased in approach, but certainly support the overall concept.

[00:44:22.58] NICK LANEMAN: All right, this kind of transitions into our sort of last planned question. Which is, with all of the evolution of technology and demand from society, how do we regulate these industries where the products are evolving faster than the regulatory environment?

[00:44:42.26] AL GASIEWSKI: So-- you go ahead.

[00:44:44.07]

[00:44:44.13] JENNIFER MANNER: No, go ahead, Al.

[00:44:45.71] AL GASIEWSKI: I've been thinking about this a little bit, when you go back to the early 1900s in the history of radio, go back to 1910 and you consider the rate of change of the frequency that which we were working at. Whether it was the latest radio band, or TV band, or microwave band, that people were using. Or whether it was the latest contention that happened to be an object of the FCC or other regulating entities.

[00:45:18.15] This frequency doubles, roughly every six years. It's the one thing I think you can kind of count on, sort of a Moore's law. It's a doubling roughly every six years. And I've been thinking about why this doubling occurs, part of it is people just wanting to develop better services, faster services, more data rate, go to higher frequencies et cetera. But part of it also, some element of it, is the regulatory framework which provides an element of symbiosis you might say, because when you do begin to regulate a certain band and all of a sudden new entities maybe can't play in that band as easily, it does force them to look to the higher frequencies and go to the more advanced technologies. So I think there is a symbiosis between regulatory and technology.

[00:46:13.73] NICK LANEMAN: Should we be calling this Gasiewski's law?

[00:46:16.99] AL GASIEWSKI: Moore's. I think Moore's got that, but I--

[00:46:19.48] NICK LANEMAN: As a corollary, this is carrier frequency, right? You're referring to carrier frequency, have you looked at the bandwidth as well? Because I know you've actually looked at data.

[00:46:26.97] AL GASIEWSKI: Yeah, yeah. Bandwidth sort of grows proportionately to carrier frequency--

[00:46:29.58] NICK LANEMAN: The cues and so on.

[00:46:29.81]

[00:46:30.04] AL GASIEWSKI: --as well.

[00:46:31.72] NICK LANEMAN: OK, great. Jennifer, go ahead.

[00:46:32.84]

[00:46:32.99] JENNIFER MANNER: I'm take it a little more into the weeds. So I think first off, we've got to pay attention to the table of applications the ratio and the table of allocation sets forth broad services, there's a lot of desire to take spectrum away and make it for an application. So we see that in the internationally with the term IMT, and identifying bands has no regulatory meaning that provides a guidepost, but we've also seen other-- we have an agenda item at the WRC to create a allocation for low power narrowband MSS satellite systems.

[00:47:10.26] And things that may or may not pan out, and we've done this before you can look at the US of course, has always allocated spectrum perhaps more narrowly than other countries, things for utilities, or public safety and so forth. And generally those have not panned out in the most efficient use of spectrum. So I'd say one, we have to go back to service based allocations. I think we have to make sure that we provide-- and I think the FCC does do a very good job on this in the US, generally does not dictate technologies that have to be used, and I think that's incredibly important.

[00:47:42.45]

[00:47:42.58] And because we picked the-- you know I used to work for the best FCC commissioner ever. There's no FCC commissioner here, so I can say-- Kathleen Abernathy, and she always talked about how if we picked a standard for cellular we would have picked the wrong standard at the FCC at that point. So I think technology-- giving flexibility to operators but you've got to pay attention to the radio services.

[00:48:04.43] And you've also got to guard a band them, we're seeing a huge issue right now at the ITU Plenipotentiary in Romania. You've also got to avoid and make sure that operations on a non interference basis are really non interference. And you're seeing that in some what we call the-- so I said, this is very weedy, I apologize-- in the plan bands at the ITU, which were bands that were developed in orbital locations for developing countries, and they're seeing increasing use by operators and that's starting to take what they view as some of their rights. And they're looking to, to perhaps put the genie back into the bottle.

[00:48:38.61]

[00:48:38.73] So I do think you have to respect the table of allocations has worked really well, whether we like to say so or not, over the past years. And you know, I've seen some blurring of this and some ways around it but I think that would be a mistake, and I think we'd end up in a much worse position on interference than we are today.

[00:48:56.75] NICK LANEMAN: Let me just say, given your comments, do we have the right set of services with the right definitions for moving forward? Because there's so much convergence of these different systems these days, and applications.

[00:49:10.86]

[00:49:11.01] JENNIFER MANNER: It's a great question. I would say, not-- But you'd have to relook at the rules if you change the definitions for the existing services, so there's a great example. And once again, this I can define ESIMs, or Earth Stations in Motion is using satellites to provide service to cruises and trucks, and so that you say those satellite services are generally considered fixed satellite services, but you look at

the use and you say, well that's mobile. And there's been a huge fight both domestically and internationally, how do you put that into that definition? We've been able to expand it, but I will tell you it's not been easy with some countries and particular raising very serious concerns about this, whether that's right or wrong.

[00:49:56.98]

[00:49:57.16] So you're probably right, I would be certainly open but then you've got to look at how that impacts it goes back to, what does that look like? Technically, it's a really nice idea but you've got incumbent services and all these bands for years, and how do you-- And that's what-- I mean, that's something the ITU does for better or worse.

[00:50:15.10] And I was talking to someone about whether I really love the process or not, and it's a love hate as noted from my notes to my secretary to send pencil so I can stick them in my eyes while I'm at meetings. But at the end of the day, we do go through the studies, and as painful it is and all the different folks are there, and if you do put in a study you at least get heard. It may not always be the right decision, there may be political decisions involved at the end of the day, I'm not saying that's right, but that sort of format actually allows you to look at it.

[00:50:47.51] NICK LANEMAN: It reminds me that at certain points after all the many amendments to the Wi-Fi standards, eventually they rolled them up into a brand new complete standards document, maybe there's a similar process that needs to be explored over a longer time scales probably with ITU. Anyone else want to jump in on this?

[00:51:03.63]

[00:51:03.77] DEREK KHLOPIN: Yeah. So kind of going a little bit of a direction to but changes in technology, but also changes into our understanding and knowledge generally particularly when we come to the regulatory process, and I raised this because-- and this is kind of what Jennifer said before, sometimes we have a goal that we want to make spectrum available for X, or we want to make a decision, we want to make it quickly at the same time we want certainty in those rules for the market participants. And there's a natural tension there and a trade off, right? And I think we need to have a little more humility and flexibility that we know what all the answers are.

[00:51:39.04] And if you think about some of these recent examples, like going back altimeters, I disagree with some comments earlier, it wasn't that the aviation industry or the FAA didn't say there were problems, they did. It was explaining them, and justifying, and doing the work, and having the study, so you could actually make decisions based on it. And now we're going through some exercises to try to maybe make some minor mitigations that will help. It was true back with the millimeter wave bands, we moved historically quickly and everyone brings up 24 gigahertz, and again we knew there was an issue for no

systems but the work wasn't done to figure out what that protection criteria may be, and we did it later. And now we're trying to put that into the rule.

[00:52:22.30]

[00:52:22.31] So I think, I think there's that-- again, as things changed and we have this interest in moving quickly and making decisions, I think we need to have humility that we can get better at things. And CBRS is another good example, we've made-- a good example, we've made incremental improvements to that along the way collaboratively working with DOD, with the industry, with the FCC, NTI, to make tweaks and we're looking at more.

[00:52:47.72] Right now we're looking at the model out there, and the SASs work with the environmental sensing capabilities, and now we're not sure those ESCs are the long term the best way to go when we're looking at new models like, we're looking at an incumbent and forming capability in the IC system that maybe could be implemented there and in other bands. Some folks want to look at like power levels, again does it make sense.

[00:53:10.81] Part of this I think is, as technology evolves quickly and as we get better at sharing and other things is-- because again, if we want to wait for the perfect answer then we're not going to make the decisions. You know, and unfortunately some of this technical work, whether it's by federal agencies or other, it takes a while. So you can delay FCC proceedings or whatnot till we get the answers perfect, or you can move forward and understand, hey, we may need to tweak some rules here along the way. And I think there needs to be an openness to that.

[00:53:38.42] NICK LANEMAN: It sort of sounds like Agile software development, iterative-

[00:53:42.15] MELISSA MIDZOR: Right.

[00:53:43.08] NICK LANEMAN: Did you want to add anything more?

[00:53:44.74]

[00:53:44.79] MELISSA MIDZOR: I agree with that, is that we need more data. We need to be-- And then what you said earlier, we need to set the expectations that things might change in five or 10 years and we need to adapt, and that's not written in stone until the end of eternity, so. And I do also want to mention before we log off is, I have a very interesting story about Doctor Moore and Moore's law from the man himself, so you'll have to come to the discussion panel this afternoon to hear about it though.

[00:54:10.24] NICK LANEMAN: That's a good play. That's a good play. All right, well that's what we prepared to discuss up here as a group,

and now is a great time for us to transition into the Q&A and discussion session. So if there are any students that want to start off the questions, please feel free. There's a student here.

[00:54:33.12] JENNIFER MANNER: He's my old intern.

[00:54:35.54] AUDIENCE: Do you want to go ahead with students.

[00:54:36.42] AUDIENCE: I'm looking around not seeing too many students, so I think I'm going to jump in. It seems like balancing harmful interference and using spectrum efficiently has always kind of leaned towards stopping the harmful interference being the main focus, should that shift now that we're kind of at the ends of useful spectrum. Should it shift toward people being more accepting of harmful interference, to find better solutions.

[00:55:05.11] DEREK KHLOPIN: Well, I'll just jump in quickly. I think there's a difference in accepting some interference and accepting harmful interference. Again, this gets to the definitional interest, right? I mean, if you're going to actually have harmful interference and as an incumbent you have those protection rights, I don't think we'll ever accept that. I think the issue becomes again, how is tolerance to interference, and again it's going to depend on the technology and the system. I mean if you're talking about a safety of life system, your risk is going to be very different than if you're, say, a commercial operator and a little bit of latency, or something's not going to really be an issue for your subscribers.

[00:55:39.97] So I think I think that depends. It kind of ties back into the you know, how can we do a better job of maybe having a framework where those type of situations can be better worked out. Oftentimes they happen in the marketplace amongst providers, but from a regulatory perspective are there tools?

[00:55:57.76] JENNIFER MANNER: So can I add in?

[00:55:58.98] NICK LANEMAN: Please.

[00:55:59.19] JENNIFER MANNER: So I fully agree with Derek, and I would call it an acceptable level of interference, but I think that's getting harder. When we look at what's going on in the standards bodies, 3GPP for development of release 18, and you've got 6G, and Horizon you're starting to see higher and higher performance metrics. So you're not going to be as tolerant of latency delay in a lot of systems, you're not going to be able to survive in the marketplace.

[00:56:28.85] So I think it's going to be to the extent you do it, it kind of goes back to what does this look like? And then, I don't know how that handles evolution over time as users demand better service, can you actually accept that level of interference. So I think that probably goes back to the debate of should we have a new definition of harmful interference, but maybe also acceptable interference.

[00:56:52.00] NICK LANEMAN: Al.

[00:56:52.66] AL GASIEWSKI: I've got a second that from the standpoint of environmental observation, and our previous panelists spoke very eloquently about the need for extremely low levels of interference for weather forecasting. But it's only getting more so as we now start thinking about climate forecasting and climate observations that will allow us to make climate assessments, not on 30 year scales where we finally see the hockey stick moving up, but rather on three year scales. And these three year scales are going to be even more important when we-- and I hate to say when-- but I just am starting to think this way, when we punch through 1/2 degree sea of global warming, because then we are really going to have to be taking measures that are much more extreme. And the precision that we will need, the level of harmful interference is going to go even lower.

[00:57:50.95] MELISSA MIDZOR: I think one thing might help that discussion, is a lot of times when there are studies they come back with a yes/no answer, it caused interference or it didn't. What we need is, you need to look at the data over the range of the total impact all the way from very low to very high so you can kind of see how much that is, and how fast it's changing. Because it might be if I change my prediction criteria a little bit, it might be that it's a very slow rise so I can actually move quite far up the chain before there's an actual large impact. Or it might be if I tweak it just a little bit, it might have an immediate response.

[00:58:24.04] But a lot of times when you see people ask the question, did you cause interference or not? It's a yes/no question. And I think we need to have the spread of data to have a conversation about where that risk might best land.

[00:58:39.65] NICK LANEMAN: I'll just maybe add that, one of the views that we're taking in SpectrumX is to push on the resiliency of receivers, not that you're ultimately going to accept harmful interference but to make them more robust. And so, resiliency, exploring trade offs, and coexistence in the spectrum is one of the big areas that we're pushing hard on.

[00:59:01.38] And I think I noticed Keith is standing here. We're standing between you all and lunch. So let me just ask that we take the opportunity to thank our panelists for their time and their insights.

[00:59:18.17] And of course, be sure to join our breakout group where Melissa is going to share that anecdote about Dr. Moore.

[00:59:23.90]

[00:59:24.34] NICK LANEMAN: Thank you.

[00:59:24.77] KEITH: Sure.

Day Two Keynote

https://www.youtube.com/watch?v=H6uyV9Vj0Fw&list=PLTAvIPZGMUXPndAsSb8280szXsRO0E_HU&index=4

[00:00:00.06] PETER TENHULA: Let's go ahead and get started here. Thank you, again, and welcome to the day two of the 2022 Silicon Flatiron Spectrum Conference. Yesterday was a lot of fun. I certainly enjoyed it. We had a great keynote speech from Austin Bonner. Some very interesting panel discussions and the breakout sessions were very interactive. And a lot of ideas came out.

[00:00:22.98] And I'm very much looking forward to seeing what the recommendations are coming out of this. And that's the topic for today, is the out brief on the actionable recommendations because I haven't had enough coffee yet. And then we'll have a final panel to discuss the pros and cons.

[00:00:39.28] So first though, we have another outstanding keynote lined up for people. It's my pleasure to introduce Tom Rondeau, who is the principle director for FutureG/5G at the United States Department of Defense Office of the Undersecretary of Defense for Research and Engineering So thank you, Tom.

[00:01:00.29] TOM RONDEAU: Good morning, everybody. All right. So, yeah so Tom Rondeau. Just joined the Undersecretary of Defense for Research and Engineering, a month ago, taking over the portfolio of 5G. Also the newly defined role of FutureG or future generation wireless networks. So like I said, a month in. So therefore, I know everything that's going on in this portfolio.

[00:01:29.11] [LAUGHS]

[00:01:31.22] But it is huge, actually. It's exciting work. It's an exciting time here. Let me make you focus on me for a second and not the slides. So I wanted to start off with a couple of remarks maybe introducing some of the philosophy that I'm bringing into this job here.

[00:01:47.94] So for those who, I know a lot of you, but for those who don't know me, I just came from a little over six years at DARPA. So I spent four years in the Microsystems Technology Office, and two in the strategic technology office building programs all the way from the antenna to the transceivers, to the digital processing at edge processing capabilities, to data protection technologies. And then applications that make use of all of those.

[00:02:19.26] So taking that holistic perspective of RF, to information, to security, as part of it. Before that, I ran the Gnu Radio Project, which is an open source software framework for software defined radio. And while I was doing that consulting for the government at the same time. So I come to this from both deep roots in the open source world and almost an academic push for new science, new technologies, new

concepts, and the ability to spread that through frameworks like in the radio, to allow people to explore faster and better.

[00:03:01.98] And I don't know how many times Julie has watched me give talks about Gnu Radio and me apologizing to him when he was at the FCC. But he would always make that face, no-- no-- no-- because I always appreciated how much you guys enjoyed the experimentation that we were trying to enable and create new ways of approaching the Spectrum or what I like to say programming the electromagnetic spectrum.

[00:03:24.35] I also have a deep route in the DOD in the classified world. So I have this weird dual hat that I have to manage and separate responsibilities there. But what's nice about that in the background there, is my work has been very clear as far as why I'm doing it. And I think that's maybe what I hope to push in today's-- this morning's talk, is Spectrum Policy, and we talk about incentives. And we talk about who's making decisions.

[00:03:55.28] I keep coming to the question of why are we making certain decisions? And I have clarity in that because I'm here to support the warfighter, I'm here to support national security. That drives the decisions that I make and the things that I think about. And that clarity helps us make decisions. It helps us push technology forward.

[00:04:12.30] So anything that we can do to make our warfighter more survivable and more lethal, which I know is a phrase that not many of you guys understand necessarily if you're not in the DOD. But that actually means a lot to us. But I want to start off I'm going to read from this one for a second because if you're from the DC area, hopefully, you've gone and seen our newest Presidential Memorial, the Eisenhower Memorial.

[00:04:34.73] So I walked down there one day. And a quote from his inaugural address has always stuck with me, that love of liberty means guarding every resource that makes freedom possible. From the sanctity of our families, and the wealth of our soil, to the genius of our scientists. And I love the fact that he put the scientist in there because I suddenly feel like he's speaking to me.

[00:04:52.20] But I like the holistic, again, that this is the United States coming together to do certain big things. And one of the big things he did, of course, was the National Highway for Defense Act, creating the interstate highway system. And it is interesting that the bill was for Defense. And he actually had economics, safety, but also national security in mind when we built the interstate highway system. So again, that's always stuck with me.

[00:05:20.55] So the other aspect that I want to convey is a little more frivolous than quoting a president's inaugural address because when I talk about the information-- when I talk about the highway system,

relating that to information and how the use of information, the use of our networks, our wireless networks, are critical to the next generation of our safety economics national security. And so if-- who here has seen the movie, "Sneakers?" 1993, one of my favorite movies.

[00:05:55.40] Ben Kingsley is a character, Cosmo, talking to Robert Redford's character, Martin. The world doesn't run by weapons anymore or energy or money. It's run by little ones and zeros, little bits of data. It's all just electrons. So I always like that because that was 1993. And so many decades later that is probably more true than it's ever been.

[00:06:14.96] And that's, again, what helps drive me is those are the things that are going to keep us safe and keep us successful as a country. So that's the background, how we think about stuff. And so let me go into the meat of this, give you some sense of how we're approaching solving some of these issues for the United States.

[00:06:38.92] Well, background on the 5G project. I was involved-- I was at DARPA at the time when this came out as we're behind. We're losing an edge in the market and national competitiveness. And Congress identified that and came to the DOD and said, can you help us? And can we push through and help make us more economically competitive? And again, also for our national security.

[00:07:04.88] So the DOD was given a big responsibility of a lot of money to execute on how we impact the 5G in the Future G world. So we created the program that I'll talk about a couple of years ago, pushing forward on how do we incentivize work in 5G? And how do we incentivize the United States to become more competitive there?

[00:07:30.13] So this involves a number of different objectives laid out to help with this. So we talk about our Accelerate portfolio, the 5G prototyping and experimentation. You've probably heard a lot about this. This at the time, I think still is maybe the single largest public investment in 5G technology by putting over $600 million into rolling out 5G installations across a dozen bases around the United States, creating test beds, and infrastructure for 5G systems that we can then use for experiments and for pushing new applications. Specifically new warfighting applications.

[00:08:12.28] But we always had a mind of the dual use concepts of those applications. What's new about 5G that enables us to create an application that is both suitable for the warfighter, and for our DOD enterprise? But also that can have shades of or be moved into commercial markets, commercial applications in the future? How can we work together with industry to make that happen? We'll talk a little bit more about some of those in a second.

[00:08:40.00] Secure 5G. That is one of the most interesting things, one of the biggest challenges that we face. We understand the value of

using dual use technologies for the government at this point for the DOD. The way that I looked at it, I gave this talk when it was 40 years ago now, when Steve Walker was the director of DARPA. And he was sitting in the front row.

[00:09:05.36] And I went over, at that point, I guess it was 2019. At that point, we estimated that R and D around the world was between 70 and $100 billion a year in 5G research. So I looked at Steve and I said, even if we're at the minimum of $70 billion, that's 20 times DARPA's budget. So will you give me all of DARPA's budget to help start this? And he blanched and said, no.

[00:09:30.14] But the point being that amount of money is, that the commercial world is pouring into this is significant. Why? Because it's that hard. It's a really difficult problem making a reliable wireless network that works as seamlessly as it does for us today. Our investments in the DOD will never compare to that. So how do we make use of that? How do we make a successful by being able to use that?

[00:09:53.79] The flip side of that is, of course, we have issues of supply chain, assurance, cybersecurity issues, just security issues in general. So if we're going to buy something off the shelf, how do we know that the information, our little ones and zeros, are protected as they're transiting these networks as we're using this equipment? So securing 5G, or what we call operating through 5G infrastructure, is a critical part of what this portfolio is doing.

[00:10:19.86] Then we talk about innovate beyond 5G. That one's being rebranded now as the Future G portfolio. This is all the new research investments that we want to make. The things that aren't necessarily part of the standard or maybe are nascent parts of the standard today in 5G as we're pushing towards advanced 5G into 6G and beyond. So we're having a number of research projects that we're investing in to try to get that going.

[00:10:44.62] And then really importantly, I keep talking about making the US competitive, securing the US. This doesn't happen without our partners and allies, doesn't happen without an interagency view of the world. So we're very dedicated to working internationally, having an entire team that works developing international agreements with allied and partner countries. And we're pursuing those pretty aggressively with a lot of the ones that make a lot of the hardware that we need to use and we need to understand and secure.

[00:11:14.31] So that's the overview of the portfolio of what we've been doing in the 5G world. So I'm going to go into a little bit of depth, a little bit more depth on each of these. So going over, this is just another visitation of what I just talked about. But let me dive into a few of these points here that are important.

[00:11:39.68] One of the things that we're looking at here, and this of course, is Spectrum conference. So of course RF technologies for accessing Spectrum are part of our portfolio. How do we make things that are able to use more of the Spectrum? The low, mid, and high band, as we call it. How do we advance technologies in the millimeter wave regime? There's a lot of hope for millimeter wave. And so far a lot of disappointment that's been behind some of that hope.

[00:12:08.15] So how do we actually create the new technologies that are going to make the amount of capacity, amount of resources in the millimeter wave bands useful for us in the DOD? And again, how do we then push that as far as a commercial success? So there's some really interesting stuff that we've got to study there.

[00:12:28.96] Spectrum sharing is, of course, continues to be a big part of the portfolio. We're studying that at some of the installations, Hill Air Force base specifically. You've heard some of the results of that already from the radar studies that were done, some of them were done at Hill Air Force base with military aircraft. Majors Field is another one down in Texas for some of the other aircraft. So we've been looking at that.

[00:12:54.01] Open architectures and virtualization. This is important to me because I think that breaking open some of these architectures is how we create a new space for innovation, but also security. And I talk about open, transparent, and secure technologies, which sound like they're competing objectives, unless you go through the process of understanding what security really means and how we actually analyze and understand what's happening inside of these boxes, inside of these networks and devices.

[00:13:26.14] The more we can understand, the more we can monitor that. But then how do you actually balance that with things like data privacy? So those are kind of competing objectives. And I think there's some interesting technology that we're looking at to go after those.

[00:13:38.53] Virtualization though as part of that is, this is where we go, well, what is the US specifically good at? What are the things? We've offloaded a lot of our technology, our manufacturing technologies. Other countries have been doing them well better. We've offloaded lots of that. Obviously, if we've been following the CHIPS for Science Act, we're trying to pull a lot of the manufacturing the microelectronics back here.

[00:14:00.62] But one thing that we're really good at is software and services in this country. So virtualization of a lot of these technologies into software is a benefit to how we can really make an impact. And how we can manage this technology space. So that's what one of the things we're going to be pushing really hard on.

[00:14:17.62] I talked a lot about the security aspects of it, this operate through. So if you look at it from the sense of we're overseas, we're

doing activities over there, how do we actually talk back to the enterprise? And how do we manage that space? What is our-- if you're familiar with the PACE Plan, the primary alternative contingency emergency communications? How does 5G, or how do these commercial wireless networks play into that plan for us to make sure that we have robust, reliable communications back to decision makers?

[00:14:50.71] But this one I want to point out to the security aspect of this one. This one is to me one of the harder discussions to have because people say we need to secure 5G. How are you going to secure 5G? And unfortunately, that is the question at hand, but it's the wrong question because if you really go down into it, you can never secure something. You can make things more secure.

[00:15:15.70] But there's always the possibility for vulnerabilities to be discovered, attacks to be realized and mitigated. But also when you say security, what part of security are you talking about? It's a huge aspect from cyber to supply chain to the RF threat attack surfaces. So being disrupted, defeated, what's-- why do I blink on the five Ds that we talk about? Deny, disrupt, defeat, degrade, those types of activities that we like to do in the electronic warfare world.

[00:15:49.92] How do we make sure that we're protecting against those in a commercial technologies, where the commercial world doesn't really have to think about things? Mathematically, interference and jamming are fairly similar. In practice, they're quite different. When you have somebody specifically trying to jam you, it's a different world than interference. So how do we actually deal with all of those as part of our security aspect?

[00:16:11.83] And then the other word on here that I think is important is zero trust. That is about the most buzzy buzzword that I think I'll probably say today, I hope. However, I do believe in it. I think that there is a path forward for zero trust architectures to be implemented. Not bought, this isn't a product that you install and you make your system zero trust compliant. This is a process and a set of protocols that we can put into place.

[00:16:38.33] And we're working very closely with the DOD's Chief Information Officer or Chief Information Office, the CIO, to work on their zero trust architecture. And hoping to use our experimentation platforms to roll out zero trust architectures, and study how they actually work and how they behave in the real world. So I think that's an exciting one that we can really make a difference on.

[00:17:01.79] Talked about our international interagency. So standards, and working with the standards bodies. This one, I'm actually going to put out there. I'm not going to go too much detail. This one I think I need help on. I want to hear from you later, throughout the day, possibly, or even our Q&A, how the DOD should engage in the standards bodies.

[00:17:24.98] I have my own thoughts and opinions on this, but I really think this is an important one for how do we incentivize US to take back key leadership roles in these standard bodies without being too heavy handed of, as I like to come in, I'm the government, I'm here to help. But how can we actually help in the right ways? And there's a lot of nuance to that.

[00:17:50.46] So I'm going to set up just a listing of items on this chart. But again, trying to give you the sense that there's a holistic set of activities that are going on through the 5G work that we're doing. And as we're executing, you can see here, again, kind of grouping into those different, those bins there, we've been working for a couple of years now to get things started. Most of our work is now on contract, and rolling, and executing.

[00:18:23.95] And you can see here, we've got a fairly large outlook on how things are going to execute and some of these projects are going to execute. We are working very closely with the DOD CIO'S Office, where a lot of this work is actually in a transition to them over the next couple of years. So that they're going to take ownership of a lot of these platforms and be able to work with them.

[00:18:43.37] So we're just kind of setting up the early stage of research and work to make all that happen. But we've got some exciting work that's executing here. And I'm going to talk a little bit of that last line in a couple of slides. So this one, I cut this one down a little bit. And it's still this much of an eye candy chart. But this one is one of the more exciting ones that I think we can talk about today that I think will hopefully help you get a sense of what we're doing in the portfolio.

[00:19:15.41] This is probably the one that's made the most amount of press. This is that investment of money into building 5G infrastructure across a whole lot of different bases and where did Keith go? Point out Keith there for helping really kick this off originally. One of the masterminds behind a lot of the work that was done to start here. He was those the 4 in the tranche one, we call it, the gray boxes there. So I want to give Keith credit for all the work that went into that.

[00:19:46.38] So each one of these was designed for a couple of reasons, geographically across the United States, across the services. So we have all of the services represented in some way in these installations. But also with specific use cases that we were trying to push forward. So you have Naval Base Coronado and Marine Corps Logistics Base Albany, Georgia.

[00:20:09.98] Smart warehousing logistics. How do we make sure that our logistic supply and resupply chains are prepped for any DOD activity? Any time we're called into action, how do we make sure that we're ready for that? Logistics is about as boring as you can get when talking about military strategy, but it's also the thing that wins wars.

[00:20:32.01] So this is critically important for us to get right. And how do we actually manage these systems because what I'm envisioning here is imagine we have activities happening in the INDOPACOM, the Pacific area of the world. We have what we call Pac Fleet, the Pacific Fleet. How do we make sure Pac Fleet is successful? Those ships are massive.

[00:20:57.26] I was talking the other night about some of our work on different Navy ships and for those, I know there are some folks from the Navy here today. One of the running monikers that I picked up when I spent some time doing some research on ships, is if you've been on one Navy ship, you've been on exactly one Navy ship. Every one of them is different. The infrastructure is different, the build out is different.

[00:21:21.92] So managing the assets, managing the Naval officers, and the crew that's on those ships, making sure that they're supplied with food and resources and weapons, is a very, very hard task. We actually do it really well. We could do it a lot better.

[00:21:38.30] And that's what we're trying to enable here out of Coronado, is how do you get those resupply ships tied into the enterprise infrastructure? So that as we're coming back into the Hawaii region, we're already prepared to resupply them with what they need. And do that more accurately and more successfully.

[00:21:57.75] So things like that are exciting. One of the other aspects that we keep running into is why 5G? You look at some of these things and you look, well, it's wireless, it's transport. A lot of people just think about this as transport. Why 5G? What's exciting about it. So we were looking at how do you stress 5G? How do you take all of those advantages of 5G and put them into practice?

[00:22:22.38] So I like to talk about it. You can look at 5G as much more bandwidth, higher data rates than we've ever seen before. Or it's lower latency. Or it's more connectivity and density of the devices. Or it's that local edge compute model. Or it's the network slicing.

[00:22:39.26] All those things individually have been done before. And there's different variations on those themes that you could pick up a technology and implement them. What 5G is to me is all those together. And it's a standard that allows us to roll that out as a working system that doesn't have to be duct taped. And baling wired together to make work in the field.

[00:23:01.92] So that's where something like the AR VR. That's why we were pushing that one early was because that does start to get to issues of when you need both the high bandwidth and the low latency to do an AR system for an operational training environment where you're at-- you're in a room like this, how do you take this room and turn it into a beachhead that we might actually have to go up and storm?

[00:23:26.33] The scale of that is hard to replicate around the United States. How can we use these kind of augmented reality systems to create that world for us? That also drives things like local edge compute because you have time to go back to the cloud for a lot of this stuff. So that was going to push the five genus of everything.

[00:23:49.01] The challenge though that we're having now, I'll say, is where do we get the AR glasses from. I don't know if you've been tracking that, but that's a promise that's still yet to be delivered, I think, commercially. So we're still excited about this. I think it's still a really good challenge and a really good technology space.

[00:24:04.91] But where we're going to get those AR VR, this is a kind of a multi-dimensional problem for us because it's supply chain. But not in the normal sense of some of the weaknesses of some of our supply chains like the chips, semiconductors, in the past year, but things that seem to have been promised for years. And are still always seem like they're another year off.

[00:24:26.27] So we're keeping an eye on that. I think the promise of that is still great. Let me talk here a little bit about each one. Let me talk about Nellis Air Force base, this one is exciting for a number of reasons. The main one is the, again, back to my quote from "Sneakers" that information is the key to success here. We have one of the most impressive sensor platforms in the world. And it's called the F 35.

[00:25:00.94] That thing pulls out so much data from its environment on every sortie that we don't know what to do with it. So how do you make sure that every time your F3524 ship comes back into-- and lands how do we take that information that it's learned? How do we craft that into new understanding of the operational environment and turn that back around? And for the next story, we have a more successful approach to managing whatever threats are out there. Electronic targets, radar systems, et cetera.

[00:25:33.58] Doing that, again, stresses the five G ness of this technology that very high bandwidth. We have, and we'll see the actual word, but we have many-- many-- many gigabytes of data to offload from that system as quickly as possible. We have a timeliness to some of that data that has to get to our data analysts and our algorithms that are running on that.

[00:25:56.70] So leveraging the bandwidth, the latency, but also that MEC. That Multi Access Edge Compute system to do that initial triage, to extract the data, to push that to the data labs, that's, again, part of that whole 5G fabric, that when you bring those together become exciting.

[00:26:14.76] Camp Pendleton is another one that I'm really a positive on. If you've been following what's happening in the DOD, General Berger the Marine Corps commandant has talked about this,

Expeditionary Advanced Base Operations, EABO. And this is Marines hopping islands, hopping locations around the world, never being targetable, and just causing a little bit of stress to whatever we're trying to accomplish out there.

[00:26:42.09] Well, how do you do that, unless you have the ability to ramp up your comms, ramp up your mobile base defense systems, your sensor and perception of the world around you? That can often take us days. We don't have days. We have minutes to set that up. So that, again, is going to stress that five genus of a highly reliable, multiple connected devices, sensor devices that are all communicating and using that Spectrum.

[00:27:08.02] It's also going to stress Spectrum policy because how do you use this to hide what you're doing? To camouflage where you are? To blend in with your environment? And to avoid that target ability that RF can provide for us? So we're studying some different concepts at Camp Pendleton to make sure that the Marines are safe and survivable when they go and deploy in the future.

[00:27:29.44] So what I'm trying to do here is taking some pictures of why some of these experiments were chosen. And what they're going to do for us operationally. Hopefully, if you're not steeped in the DOD world, some of these have at least shown shades of capabilities from a commercial market perspective. So how do we, as the vanguard of funding these types of research activities, lead the way for technologies that are going to be successful commercially tomorrow?

[00:27:57.09] That's kind of the balance that we've been trying to create here. Obviously, very defense and DOD focused, but we're working with commercial industry. We have all the mobile network operators in the US working with us. We're working with a lot of the vendors provided to do all this. So we're incentivizing them to get started on some of those next generation applications today.

[00:28:20.21] So that's the accelerate or base prototype and experimentation portfolio. We also have, as I said, this idea of operate through in the security. And so when you look at DOD operations around the world, you have you kind of bucket them into three bins, over, clandestine, and covert operations.

[00:28:44.17] Obviously, I'm not going to talk about those latter two but you know that they are roles that the DOD plays. And how do we make sure, again, that those are successful in doing the jobs that they need to do, survivable, getting the information getting the activities that are required to make us successful out there?

[00:29:00.76] How do we communicate with them safely and securely? And, again, we go back to that PACE Plan, the primary, alternative, contingency, and emergency. Everybody goes out with a PACE plan. And most of the time we never hear from them until they come back.

How do we actually create a world where we have more rapid communications and understanding what's happening in the field.

[00:29:22.99] But from an overt perspective. That's the easy one too. We've got bases all over the world Korea, Okinawa, a lot of places in Europe. Everybody knows were there. How do we make sure that we're securely using those systems and managing the traffic that comes back from them as we're were transiting the world of a 5G infrastructure?

[00:29:48.13] And one thing you probably know is Huawei is about 35 ish per cent of the RAN, the radio access network market. So if you're moving around the world from any one of these locations, and if you've seen the Belt and Road Initiative map laydown of where those installations are going around the world, there is a high likelihood that we're transmitting something that we know we can't trust.

[00:30:08.17] So how do we put trusted capabilities onto our networks to enable that movement of capabilities back to the enterprise, and back to the decision makers? So a lot of work being done here. Part of this is that black box issue that we have of commercial technology. We don't necessarily know what's happening inside of it. We don't have a set of eyes on it. So how do we actually again trust those systems and create those capabilities?

[00:30:35.77] How do we deploy our own private networks? But those private networks are great for internal communications. How do you actually push them back to the enterprise? And all that. Really difficult challenges in this space. I mean this is probably the most difficult part of the portfolio that we have.

[00:30:52.46] And then we've got the innovative beyond 5G. So this one we're going to continue to evolve in what we care about and what things we can push. These technologies up in that blue box are some of our leading research efforts that we have going on today that are executing. We should have results on it over the next half year to a year for different projects that we have.

[00:31:19.17] But you can see, if you've been following the 5G world, and if you're in this audience, I don't think any of these are probably surprises to you. But just want to make sure that we are tracking a lot of them. Beamforming and this multiple input multiple output, terrestrial, non-terrestrial networks, So NTN, non-terrestrial networks is becoming a key component of future generation technologies.

[00:31:44.63] We want to make sure that we're on the forefront of that. And again, pushing that because that is part of that multiple approach to getting data back and moving data around the world. You've got your 5G bubbles, but how do you actually get that, again, back to the enterprise? So lots of things happening here and lots of things that are working directly with the services to be laid down onto the experimentation that we can have with the services.

[00:32:09.80] A little teaser we just came back from working down at Virginia Beach with the SEALS, SEAL Team 18, which if you've never heard of that. It's because they're fairly new. It's one of the old support teams that's just been rebranded as an official team, Team 18. Actually doing some activities with the Stiletto which is a really cool Navy platform.

[00:32:29.28] If you've never seen it, it's a pretty-- I thought it was exciting because I did an operation or-- not an operation, an experiment with it a couple of years ago. And I went to the Navy. There's a Commodore sitting there, one star. And I go to him, I was like yeah, so I need to use your boat. But we got to put an antenna on there. Like what's the authority that we're going to need to go through?

[00:32:50.63] And if you've ever tried to put an antenna on a ship before, it's about a four to five year process. And the guy was like, yeah, wherever you want. Really? He's like, yeah, you want to drill a hole in the boat and just run your cables wherever? And I was like-- it was the most amazing thing I've ever heard the Navy say. But it's a cool ship because it allows you to do that kind of experimentation.

[00:33:11.83] And so we've actually been doing mobile 5G on a boat out at sea using the Stiletto. So some cool results to be brought back from there. So I'm going to finish up here on the next couple of minutes just talking about some of these specific activities that we're creating in this open space because I really do believe that creating an open technology base for innovation and to execute new ideas on is important.

[00:33:44.63] When you think about a lot of the promises of 5G and a lot of the application spaces that people have been talking about, how do we actually lay those down on real world working capabilities, breaking these things open, and allowing us to have that exploration? Think about the '80s and '90s innovation space for the internet.

[00:34:04.43] A lot of that was based on those open technologies back then. I'd love to be able to recreate that kind of energy, that kind of work that we can do here with a wireless networking world. So big, big push on open interfaces, working with Open RN. My team, Amanda Toman, who's my deputy principal director, who's been the acting director for the last year.

[00:34:31.19] She was just out here in Boulder last week with CableLabs showing off the results and congratulating the finalist of the phase one of our 5G challenge, which was all about studying open interfaces and connecting different vendor devices together. And showing that if you define the interfaces, you can actually build a system well. We're now going to be working towards phase two of that challenge. And I think we've got some exciting stuff planned for how that's going to play into this.

[00:35:00.69] So trying to build out that ORAN, working with them. But also it's not just open interfaces, and it's not just open architectures. We're covered in open architectures in the DOD these days. I don't care for open architectures, unless you at least have a reference implementation to go along with it. Somebody's got to show you how it can be done and how you can actually integrate these things together.

[00:35:25.08] So when DARPA and RNE collaborated early on in kind of defining what we wanted to do with 5G, a couple of the things that we worked to find were projects to create open source technologies, open source software technologies, that could be used to create this innovation space.

[00:35:46.53] So open programmable secure, that one was looking at the market of, again, these Black boxes and a lot of it that domination of Huawei in that space and trying to say if we can open source this, much like Linux did for the internet, let's open source the software stack that goes on top of the hardware. And that gives us more insight, more ability to observe what's happening in there, and we can create better technologies, we can create more secure systems on there.

[00:36:14.37] So again, open programmable secure, all three of those together are important words for this project. So we're studying things like how do you make sure that network slices are secure and don't leak information? They're studying how IoT devices, internet of things, little sensors, these are very battery limited systems, which means that most of the time, the first thing that you're going to drop is authentication and security because that takes energy to do. So we're studying new ways of approaching that to minimize the energy consumption, but also making them secure.

[00:36:48.11] What we didn't do in OPS is create an open source 5G network core. We thought about it, until I got in touch with my friends at the Linux Foundation, and they've already been working on that 5G blueprint. So they've already been investing, the commercial world has already been investing in creating that open source network core.

[00:37:07.25] So we now-- so DARPA got to get rid of the we, I'm no longer at DARPA. DARPA has a credo with the Linux Foundation to work together on building out those security overlays on top of the open source core. We also have this Multi Ops 5G Joint Independent Testing Option. And I'm glad that acronym is written out there because I can never remember what MOJITO stands for.

[00:37:31.88] But MOJITO is an exciting possibility for this experimentation that I talk about. This is to put these open source cores in multiple installations of those bases that I showed you on that map overlay of the United States. If we can actually connect all of these together through these cores, have multiple cores, but all actually jointly networked together, we can start scaling our experiments that can represent real data, real traffic and real problems in the real world.

[00:38:06.53] Right now we have a lot of islands of experimentation. And they're all useful in their own right but the scaling problem of a real wireless network needs to happen for us to really get our arms around it. And so that's what we're trying to push with MOJITO, is how do we actually connect all of these together and create networks at scale that we can use to study.

[00:38:26.79] So that's the rundown of the portfolio of what we're doing in 5G. I think the lessons learned this is, I think, we now know this is inevitable. We have to figure out how to use this for the DOD. It's exciting that we've been able to push the technology and incentivize the commercial companies to-- and pay them to do exciting work of application and technology development that the commercial world, maybe not was ready for but was envisioning.

[00:38:59.34] So we're helping bridge that gap into some exciting new capabilities. And I think you're going to see over the next year as we're really pushing with a lot of the now existing or building up these test beds and executing. So I hope next year, I can come here and show you a lot of results of what's been happening in these things, not just the vision of what can happen. And then I think we can start rolling from there.

[00:39:25.62] And with that, I'll close it out and take some questions.

[00:39:29.57] OK. Why does--

[00:39:31.21] [APPLAUSE]

[00:39:41.35] TOM RONDEAU: Yeah. Show in the back. Mic's coming up to you.

[00:39:46.84] AUDIENCE: All right. You mentioned it's kind of a balancing, not a balancing act. You're obviously focused on defense purposes in your research. But that you kind of keep an eye towards future commercial uses. Are you able to elaborate on what steps you take throughout the process and kind of keeping those future uses in mind and looking forward?

[00:40:04.53] TOM RONDEAU: Yeah. That's a great question. Thank you. The philosophy behind this is if we are to be able to successfully utilize commercial technologies securely, that doesn't matter unless there is a robust market for those technologies to exist for us to pull from. So then in practicality, we're using the other transactions authority for contracting with commercial entities.

[00:40:34.23] So instead of using the Federal Acquisition Regulation Rules for most DOD contracts, we're actually building agreements with companies. They're not contracts, they're agreements, where we can actually jointly invest and jointly work on technologies that are important to both of us. So that, again, it's not us going and saying, this is important. We're going to pay you $1 billion, and go develop this

one off, just for our purposes. It's what are the things that are important to both of us so that we can understand what's going to help them make that commercially successful and make sure that there is that sustainable supply chain of technologies that we can continue to pull from.

[00:41:15.77] ANTON MONK: Hi. Anton Monk with Viasat. Thanks for the presentation. I actually think is a perfect intersection with what you presented from the OUSD standpoint and Spectrum. So we're participating in a number of the DOD OUSD projects. I would say one of the biggest concerns is not actually the 5G technology, it's Spectrum access.

[00:41:37.22] And the, I would say, the lack of a clear model or plan, so that we've had to go and say, OK, here's CBRS. That's available to us. Or there's some federal priority millimeter wave bands. But other than that you have to go and partner with the MNOs to find something. So there isn't really a clear path for testing in the US. Outside, who knows what's going to happen. I'm just interested in your thoughts on that.

[00:42:04.50] TOM RONDEAU: Yeah, that is a big challenge for us. We have agreements, we've been working with the MNOs, the big three in the US. We're also working with CBRS Spectrum specifically down in Albany, they're using CBRS down there. But you're absolutely right. Even CBRS, we're just doing the generalized access model. And only getting some megahertz of Spectrum here and there.

[00:42:31.22] With the MNOs, we come to the table. It's like that scene in "Empire Strikes Back" that still keeps getting worse every time, every day. They promise access to Spectrum. And then we go and want to execute on that also. And we're told oh, hold on, hold on. So yes, that definitely is a vexing challenge. And frankly one that I was disappointed in not wanting to do more Spectrum policy in my current work and realizing that that's going to be a huge part of my job, is to try to figure that out with those folks.

[00:43:01.31] We are working with them. We've been developing better relations with them to allow us to have more access to the Spectrum specific to the base installations. So the fact that we do have these testbeds on military bases where we do have some amount of control over the Spectrum, and kind of geographically isolated in some senses helps us with that question. But it does vex us with every time we want to try to run an experiment, that we've got to work through this.

[00:43:38.34] I will say that another aspect of this that we're studying right now is it was perceived as a real benefit to go to these private wireless networks to establish them so that we could actually have some kind of control ownership and management of that stuff. But it didn't solve the Spectrum problem. And we may have just offloaded the fact that we used to pay $50,000 for a radio, and now we pay $500 for a

radio. But we have to pay a license fee every time we access that network.

[00:44:10.48] So the trade space there is also, from an economic perspective, is also vexing. We've got to figure that out. The only thing I can say is what we're doing right there is continuing working with the MNOs. And trying to build better approaches so that we can establish a cadence for being able to use Spectrum more effectively.

[00:44:31.38] The challenge that I have there is that doesn't scale, doesn't scale beyond the base. And how do we actually make that work? That's a really, really tough challenge. I got one more over there. Keith, how much time we got?

[00:44:45.94] MARK WALKER: Hello. Mark Walker. I'm from CableLabs. On the Spectrum access challenge you just mentioned, how do you think about 5G NRU, New Radio Unlicensed technologies? Do those fit into your portfolio? Or your thinking it all?

[00:45:00.05] TOM RONDEAU: They should. So we definitely are tracking that. We are definitely thinking about those sort of things. We actually don't have anything active right now. I think that's all I'll say on that. As we're pushing to the future with more of the ORAN technologies, and more of the new approaches that we have. But currently we're just working with the licensed Spectrum. I think we had more down here. Sorry.

[00:45:35.13] WESTON PATTON: Weston Patton. I want to thank you for your excellent presentation. I was particularly excited to hear that DARPA has a creative with the Linux Foundation on the open 5G core. I wasn't aware of that. I want to ask you, and this might be outside your remit, about receiver standards.

[00:45:54.26] As demand for wireless services continues to explode, we're not going to have enough Spectrum to allow sloppy receivers to continue to preclude use of adjacent Spectrum. Now the 3G, the most ubiquitous radios in the world are cell phones. And the 3GPP standard includes something called adjacent signal rejection, that requires your cell phone to not accept interference from adjacent signals.

[00:46:32.75] And right now, there are several prominent examples in the US of sloppy receivers precluding the use of adjacent Spectrum. You've got the aviation community with Verizon, and--

[00:46:53.74] TOM RONDEAU: Just for time's sake, I get--

[00:46:56.43] ESTIN PEDANT: Are you doing any work on receiver's standards? Because right now DOD is using political muscle to prevent poor legato from activating its Spectrum. And you smile, but

[00:47:09.93] TOM RONDEAU: Well, you said poor legato--

[00:47:11.25] [LAUGHING]

[00:47:12.86] ESTIN PEDANT: I think it's shameful. And I hope that you would be doing work on receiver standards.

[00:47:18.32] TOM RONDEAU: So that-- I think you're right-- is outside of my area. That's where DOD CIO would probably have more of a specific response to. What I'm interested in are technologies that help coexistence and the ability to operate adjacent co channel.

[00:47:38.98] Lots of things with your interference or rejection, lots of better filtering technologies, adaptive filtering technologies, I don't have enough information right now to give you any sense of where I stand on receiver's specifications directly. Just that those technologies are going to be helpful for us as we're going into these congestion and contested environments anyways. And how they help in the commercial sector, that's where we're, from an R&D perspective, pushing the technology in the research.

[00:48:07.08] ESTIN PEDANT: Thank you.

[00:48:08.40] PETER TENHULA: OK. I think we're out of time here. Thanks, Tom.

[00:48:11.81] [APPLAUSE]

Recommendations Outbriefs

https://www.youtube.com/watch?v=4BnnV_5NO1k&list=PLTAvIPZGMUXPndAsSb8280szXsRO0E_HU&index=5

[00:00:00.93] PETER TENHULA: Hey. Good morning.

[00:00:03.66] AUDIENCE: Good morning.

[00:00:05.12] AUDIENCE: Hey.

[00:00:06.09] PETER TENHULA: For those who weren't here yesterday or maybe had too much to drink last night, quick recap.

[00:00:12.97] [LAUGHTER]

[00:00:13.83] Yesterday afternoon, we held two separate concurrent breakout sessions, a new format for Silicon Flatirons. Building on the theme of the first panel from yesterday morning, one breakout session tackled solutions addressing the root causes of interference conflicts. And we tasked the other breakout group with developing technical, economic, or regulatory recommendations for resolving interference conflicts, which was also the topic for panel two yesterday.

[00:00:41.52] Each group included our panelists from yesterday morning, along with several invited discussants and other conference attendees. We called them interlopers. Each session was conducted under Chatham House Rules. That is, anyone who participated in the group was free to use the information from the discussion but is not allowed to reveal who made any particular comment or their affiliation. This no-attribution rule is designed to increase openness of discussion, which I hope we we're able to achieve.

[00:01:18.36] My name is Peter Tenhula. I'll be the moderator for this panel, this out brief session. I'm senior fellow with the spectrum policy initiative at Silicon Flatirons, and I'm sure our two main presenters this morning's first panel had no idea what they were getting into when Keith asked them to help with the conference. They had quite a heavy lift. With--

[00:01:43.38] Nick and David deserve huge thanks for moderating the panels yesterday and then facilitating each of the breakout sessions. And now they're here to report out on the results of their group's deliberations. Nick Laneman is from the University of Notre Dame and is director of the Spectrum Center. His bio is on the website. David Redl is the founder and CEO of Salt Point strategies and also the Silicon Flatiron senior fellow with the spectrum policy initiative.

[00:02:13.83] Joining David and Nick will be two student rapporteurs, two of the four. We've got Jackson McNeil, law student L2. Second-year law student. Is that correct? And Graham Stephenson. Also, second year?

[00:02:33.16] GRAHAM STEVENSON: Third year.

[00:02:33.48] PETER TENHULA: Third year. Third-year law student. Also, he was the author-- co-author of last year's spectrum conference report. They had help from Sean Harms. No relation to Harms Claim Threshold.

[00:02:46.65] [LAUGHTER]

[00:02:48.39] And hopefully, I get this pronouncement. Zelith Botan? Is that correct? Who also helped in group two.

[00:02:57.63] Before we get into the substance of the breakout group's recommendations, I'm going to ask David and Nick first briefly kind of their thoughts and reactions to the breakout format that we used for the conference. Specifically and briefly, let us know what worked well and what could we do better if Silicon Flatirons were to try this type of format again. Nick, do you want to start off?

[00:03:26.82] NICK LANEMAN: Oh, pick on me first?

[00:03:27.87] PETER TENHULA: Yeah.

[00:03:30.19] NICK LANEMAN: I--

[00:03:30.65] PETER TENHULA: And thank you again. Thank you.

[00:03:33.18] NICK LANEMAN: It was my pleasure to try it out. I improvised. I would say never having been at the Aspen Institute previously, I didn't exactly the protocols with the name cards.

[00:03:47.88] I started engaging the whole room. I didn't necessarily prioritize the discussants. So if I was supposed to have done that-- a better job there, I apologize.

[00:03:57.57] It was a long session. Sorry, this seems a little bit low. Thankfully I sat down for the first hour and a half, and then I was able to stand up and do some-- it was really helpful to have the poster boards to collect some thoughts.

[00:04:18.95] I enjoyed the format. I think-- there was some for my own improvement. I think being clear up front whose the audience or audiences for the recommendations and communicating that clearly to those involved in the breakout. I sort of just said, broadly speaking, the spectrum ecosystem. But otherwise, yeah, it was great.

[00:04:45.07] And I appreciate everybody's input. It was pretty lively. I think we had the bigger group. Sorry, David. But--

[00:04:51.19] [LAUGHTER]

[00:04:53.60] DAVID REDL: Having a small group was probably easier. Nothing to apologize for there.

[00:04:56.76] PETER TENHULA: What about you, David? Go ahead.

[00:04:58.35] DAVID REDL: I actually enjoyed the format as well. I think a couple of things. One, we had great student support in our group,

which definitely made it a lot easier. Graham was in the front of the room, sort of live scribing onto the screen what was being said so that people could keep track of what had been sort of bounce back and forth where we were in the different topic points.

[00:05:20.27] I think it's good to have discussants named so that you make sure you have a critical mass of people, but we were pretty clear that everybody in the room should be a participant, and that was to our benefit. Because some of the people that were not named discussants or panelists were some of the most active participants and had some of the most salient points to make. So I think it's a great format.

[00:05:39.59] I will admit, when I saw the format, I thought oh dear god, the entire afternoon in a breakout room. This is going to end in disaster. But it, actually, was a really great conversation. Everyone was very engaged, and I really appreciated everyone's inputs.

[00:05:52.56] AUDIENCE: I think that if what Jackson Mcneal--

[00:05:56.54] GRAHAM STEVENSON: I thought I was going to get carpal tunnel but other than that--

[00:05:58.88] [LAUGHTER]

[00:06:00.74] From a student perspective, I found it really engaging and interesting to see how the ideas would flow and how discussions happen at a high level between people who are really well-informed about these types of things. I think it was extremely helpful as someone who's still just entering this field. And, yeah, I thoroughly enjoyed it. I thought it was a lot of fun.

[00:06:23.54] JACKSON MCNEAL: Yeah, it's like what Graham said. I was kind of impressed. We had a couple of moments where I don't want to say the conversation was getting off the rails, but like the ability of the group to like self regulate, and like no offense if Nick had a bad idea about how to proceed in the breakout session, people did not hesitate to say, like, let's do it this way instead.

[00:06:40.40] And Nick was a very good moderator in that he was either exercised his discretion or, if he saw that the group might have had a good idea, we went with their suggestions. So I thought it flowed really well. Particularly having, like David mentioned, that openness to kind of speak off the record and candidly.

[00:06:56.00] PETER TENHULA: Right. And Nick mentioned that the Aspen Institute and we shamelessly kind of stole this format or modera-- from conferences that Redl and I have been to like at the Aspen Institute for their spectrum conferences where-- but none of those are public. So they kind of have a plenary session, they break out and then report back into another plenary session but none of it's public. Here we're kind of combining public conference with these non-public breakouts that are under the Chatham House Rules. I mentioned, and

you guys report out, please make sure no names or affiliations are mentioned or attributed to any of the particular recommendations. You have one more thought.

[00:07:38.66] NICK LANEMAN: One more observation. The break seemed a little short. It was a little bit hard to get people back from the break. So maybe another 10 minutes or so would have been helpful. Because they got involved in side conversations that ideally came back to the discussion.

[00:07:52.37] PETER TENHULA: Right. Yeah, and a few people maybe kind of roamed between the two, I think. A non-- maybe non-discussants non-- so it's we'll take those lessons learned from and try to apply it before.

[00:08:07.83] So now we're going to take about 10 to 15 minutes each to present the group's recommended actions and next steps that will address the recurring spectrum conflicts. And with any help, you need from the students if you want the clicker proceed.

[00:08:22.49] DAVID REDL: Sure.

[00:08:22.79] PETER TENHULA: David, your slides are up first.

[00:08:24.14] DAVID REDL: Why not? So we talked ahead of time. I'm going to present the findings that the group came to, and Graham is going to cover the recommendations that came out of that. So the group came together in the beginning. And frankly, I started off the conversation, and I'll out myself four things I say. I think I've allowed under Chatham House to out myself.

[00:08:43.19] I started off the conversation with the concept of do we need structural change in the way we make spectrum policy decisions as a way to alleviate the causes at the end of the day. Frankly, the concern was not there. The group said, essentially, that conflicts are increasing the result. Instead of root causes of power differential and other things that are changing, really it's the ability to make more available and the process by which we are starting with the assumption that we have to make more available in a certain way and driving that through the legislative and regulatory process without participation.

[00:09:23.72] The group came to the conclusion that the process is not fundamentally broken. That we don't need wholesale change to the structures. That at bottom, while the FCC and NCAA may not be perfect, the FCC and NCAA are, at a minimum, the least worst option available to the United States government.

[00:09:40.02] [LAUGHTER]

[00:09:40.38] And so it's what we've got, so let's stick with it. But it will require a rethinking of the process of how we come up to the

conclusion that we're going to make a new use available to surface and address concerns earlier in the process.

[00:09:55.52] One of the major themes that came up early in the conversation was the disparate timelines that we talk about both in policy, whether driven by Congress's processes, CBO scoring takes a 10-year look at things, sometimes the operational lifetime of a system is in the decades. And those are not necessarily going to line up in a way and not being addressed in the current structure in a way that's going to produce positive outcomes. So having looked at that, we thought instead of focusing on changing the structures, it was pretty clear that the group wanted to focus more on reforming the process in a way that takes everyone into account in a more holistic way. So Graham, with that, if you want to go ahead, I'll switch over to you, and we can talk about what the outputs were.

[00:10:39.83] GRAHAM STEVENSON: Absolutely. So coming out of those discussions and those findings, there was general consensus in the group that a congressional-led approach should adopt an inclusive and iterative process for new allocations. And it should all start with reports on new allocations, not necessarily with requirement for auctions. And in that sense, we need to look forward, and Congress should be focused on empirical findings as they develop new legislation. And those should be developed collaboratively by the FCC and NTIA so that there's not one dominant agency involved in the process and that there are multiple perspectives taken into consideration in the development of this legislation.

[00:11:26.79] These reports should be focused on efficiency. In order for government systems to answer the question, can the capabilities of a government system or platform meet its mission more effectively through a spectrally efficient improvements in equipment or components? This is an essential question to consider the efficiency and take that into account for how we're developing policy.

[00:11:50.19] DAVID REDL: If I can. I think part of the challenge we faced when we looked at efficiency. And we talked about this in the panel yesterday before the discussion group is that it's not something that has a concrete definition.

[00:11:58.98] And there was a lot of debate within the group about how do you take the difference between a system that, by definition, requires a broad bandwidth in order to surface an individual signal. You know how-- if you're looking for one signal in a very broad swath of spectrum like a interceptor radar, how do you address that efficiency question? So this was sort of the best effort we had to trying to look at a way to put together something that was broad enough to encompass all different government uses but granular enough to actually produce an outcome.

[00:12:29.16] GRAHAM STEVENSON: Absolutely. And then moving along. Obviously, we did not have a consistent-- consensus on every point as David just addressed. But, obviously, one-stop legislation is not the end all be all of everything. So obviously, subsequent legislation should always be developed consistently with the reports that are developed by FCC and NTIA.

[00:12:52.53] And those should look beyond revenue-based approaches and consider a wide variety of factors in addressing and understanding efficiency and the highest and best use of spectrum. Obviously, Congress has taken steps to address this process, as David kindly put in the slide here. The PATHSS process is a good potential model for how we can work cooperatively to go through the process and figure out the best way to make new allocations and uses available for spectrum.

[00:13:28.58] AUDIENCE: Which one do you get?

[00:13:30.87] DAVID REDL: The infrastructure bill.

[00:13:32.35] AUDIENCE: OK.

[00:13:32.84] [LAUGHTER]

[00:13:34.80] GRAHAM STEVENSON: And, obviously, all the players involved in the process would benefit hugely from the inclusion of in-house expertise in all levels of leadership, both from the very top and at the staff level in regards to spectrum policy. If you have anything to add, David?

[00:13:51.42] DAVID REDL: Yeah, I think it's worth noting that we also addressed, within the group, that these are lofty and aspirational and very difficult to actually implement. Congress does not take well to being told what to do. So the notion that you're going to tell Congress this is how it should go is certainly not necessarily in the cards, but it's an aspirational process. A view that maybe through the back and forth between the executive branch agencies and their oversight committees, we can produce a process that looks more holistically at how to meet commercial and federal needs as we try to pack more into the same amount of spectrum.

[00:14:26.34] With respect to the last bullet there, all players would benefit from in-house expertise. We had a pretty robust conversation about when things worked and when things don't. And I think we all had an agreement that perhaps the high watermark for cooperation amongst the federal agencies, the NTIA, the FCC, and Congress, was the AWS three process.

[00:14:48.42] And there was a pretty strong focus at that time on who was where within the federal government. The leadership within the legislature deferring to expertise and not necessarily having a predetermined outcome. As I said at the time, I think we realized that

was lightning in a bottle, but that doesn't mean we shouldn't strive to create the conditions for additional lightning.

[00:15:09.54] GRAHAM STEVENSON: Absolutely.

[00:15:10.20] DAVID REDL: With that, I think that's a pretty good summary of where we ended.

[00:15:15.04] PETER TENHULA: OK. Pass the clicker. Group two.

[00:15:22.89] NICK LANEMAN: So I'll set the stage. I kind of summarize the session at a high level, then hand off to Jackson for the recommendations. So we kind of had two phases of our breakout. The first phase-- and you've heard of zero trust architectures, I had a zero prep breakout session.

[00:15:44.17] And so Keith just basically threw me into the breakout. I don't know if this was on purpose or not on purpose, but-- and so I just reacted and kind of picked up from the discussion of the panel. So we spent the first part of the session talking about suggestions for inclusion in the National Spectrum Strategy. We're not going to summarize those recommendations. It was pretty nebulous and pretty far-reaching discussion, which hopefully will distill down through the editorial process from the meeting notes.

[00:16:17.20] The second part of the session, I got a little bit more tangible, and I challenged the group before we broke to come up with actionable recommendations. Who needs to do what by when to solve some of these interference conflicts. And so we had a lot of discussion. We took a lot of inputs. We came up with 11 potential recommendations through that discussion.

[00:16:39.79] It was hard to get timelines out of the group. So you'll see a few comments that we don't necessarily have hard fast timelines. But then what we did is we down-selected to five kind of at the end of the session. In very quick order, we voted on them. And so, with that, I'll hand it off to Jackson to summarize those recommendations.

[00:16:57.88] JACKSON MCNEAL: Awesome. And like Nick, I'm kind of on a no-prep schedule here. They told me I was presenting at 8:00 PM last night, so--

[00:17:03.34] [LAUGHTER]

[00:17:03.67] --I'll do my best. But you get a bunch of lawyers, engineers, and scientists in a room, and we're going to argue about definitions. And so, I think, our first-- there was a really general bend in the conversation towards the need for definitional clarity, particularly talking about interference issues.

[00:17:18.35] And so, one of our first actionable solutions was performing more better and varied measurements of radio propagation interference scenarios performance degradations. We said that needs

to be done through the NSF, through NTIA, and through NIST, the normal players you would expect. But it's kind of just a necessary step if you want to address harmful interference to be able to model more precisely RF propagation.

[00:17:39.37] And I don't that-- I think we had general consensus on this, but I think there was some pretty healthy debate about what effect it would even to have to be doing these like greater RF modelings. Whether or not it's worth $25 to $30 million to do it, or if as you'll see in one of our later solutions, we talked about the cost of remediation, whether or not we're overwhelming the own benefit of doing this advanced testing. And as Nick prefaced, we had no time frame on this, exactly. But Nick, do you have more you can add on that?

[00:18:09.76] NICK LANEMAN: The needed measurements and/or models, there was some discussion about trying to flesh that out. And I think we probably would want to lean on ITS to help flesh out those details.

[00:18:21.99] AUDIENCE: Right.

[00:18:23.28] NICK LANEMAN: Without naming names.

[00:18:25.16] JACKSON MCNEAL: [LAUGHTER] And so one of our second solutions going back to that definitional clarity. Kind of having an idea of what we're talking about, even when we start talking about resolving interference conflicts, is developing a framework. Again, we're going to punt it to NIST to actually explain what that means. But for harmful interference that includes mission impact and technology impact, we had FCCs the NCAA under their new memorandum as the groups, along with stakeholders, kind of pursuing the implementation of these frameworks. Again, we didn't discuss costs or a specific time frame for this one.

[00:18:58.35] But again, it's about being able to be clear about what we're talking about when we talk about interference conflicts. I think so much of these issues stem from people having different understandings of what interference is, different understandings of what harmful interference is and different understandings of the actual value of addressing that and how we should address that, and who should be addressing it. So that was a definite, I think, theme throughout our conversation. Was people just wanted more clarity when we have these conversations about how to even start having this conversation, and particularly with the framework discussion, how to start having this conversation and how to implement a way to talk about harmful interference that we can repeat so we can use this framework across different scenarios.

[00:19:38.28] And I think there was healthy debate about whether or not that's realistic or not. Because, as we all know, the RF environment's incredibly unique on a case-by-case basis. But having a general starting

point, I think, was something people agreed would be really helpful in addressing this. But Nick.

[00:19:53.47] NICK LANEMAN: Go ahead.

[00:19:56.38] JACKSON MCNEAL: We had assess, create, and characterize interference mitigation technologies for expanding coexistence opportunities, example MIMO. This should be pursued by Spectrum X, NRDZ, testing organizations, various research funding organizations. That's 10 million, not just $10. Although it would be lovely in the first two years.

[00:20:13.93] [LAUGHTER].

[00:20:14.86] And 50 million over five. This goes a little bit-- we ended up with, I think, two solutions that kind of address the R&D aspect of the solution, but I think there was general consensus that there needs to be work done to expand our technological approach. And that means-- and this is actually Nick, where I think you should take over a little bit. Because they started talking about the tech, and I was like, all right, I'm in Law School I appreciate the conversation, but--

[00:20:39.45] [LAUGHTER].

[00:20:40.84] --I did my best to listen. But I'll give the broad stroke and let Nick dive in here. I think that we need to open up the amount of avenues we think about when we think about interference mitigation technologies and who we get involved and being more intentional and thoughtful in how we pursue solutions to harmful interference issues. But Nick, I think you'd give better character to that.

[00:21:00.67] NICK LANEMAN: Yeah. The theme here is that there's just-- there are many more knobs to these systems, right. In particular, the driving example that was brought up repeatedly throughout the discussion is adaptive antenna systems. Larger and larger rays, more and more sophisticated beamforming that gives us a lot more ability to squeeze more uses into the spectrum, but that has not been completely examined in terms of mitigation technology for promoting coexistence.

[00:21:31.42] And so that was the theme of this. Is to really pursue mitigation, not avoiding interference but mitigating it, managing it. There's a lot of technology that's been developed in the cellular world, for example, but spreading that out across disparate use cases and coexistence mechanisms.

[00:21:52.68] JACKSON MCNEAL: And then four. We reworded this one from its original formulation. I was a little less kind, but we decided to go with a positive language. Embrace risk-informed over worst-case interference analysis, including economic factors such as cost of remediation.

[00:22:09.39] To give a point on this one being a pretty universally accepted suggestion, this should be adopted by the FCC and NTIA immediately. I think-- I don't have to say it aloud. We've all been aware of how worst-case scenario interference analysis have kind guided the conversation in the past few years.

[00:22:24.42] And how, I think, there was clear consensus in the group that was a source of frustration, particularly because it's-- I mean, you have different actors with different margins of error allowed, particularly in some conflicts. But here, I think everyone agreed that risk-informed analysis is going to give you better results. And I think give people more flexibility to deal with the issues in a way that's appropriate to the actual issue posed rather than having groups dueling about whether or not this guy is going to fall down about this particular issue happening or not. So Nick, do you have anything?

[00:22:59.43] NICK LANEMAN: Yeah, the other term that didn't quite make it into this bumper sticker version is this notion of total cost of the process. There's the costs associated with developing the rules, and there's costs associated with deploying the systems, updating the rules, implementing enforcement mechanisms. So thinking about all costs in this timeline was the suggestion here.

[00:23:28.13] JACKSON MCNEAL: And then at last was pursued disruptive technologies and new incentives for spectrum sharing. We saw Spectrum X, NRDZ, NSF, DARPA, public-private partnerships. The SRC, or the Semiconductor Research Center, got brought up as sort of an aspirational model in terms of doing research into disruptive tech for spectrum use. We didn't talk about cost and time frames. I thought this was a really interesting discussion.

[00:23:52.37] Again, I'm not a scientist, so some of it went over my head. But I thought the discussion about how we introduce disruptive technology was really interesting. I think there is a consensus that a lot of the spectrum research going on right now is incremental. We're trying to improve our performance in pretty discrete ways that are compared to last generation. We're doing this 5% better versus.

[00:24:14.39] This discussion, I think, really focused on disruptive technology. And it's easy to say, yeah, like go out and invent something that completely revolutionized everything. But it was-- this discussion more focused on how do we identify discrete ways to incentivize that kind of development and to focus our research in such a way that we do have the next technology that kind of changes the field but.

[00:24:35.75] NICK LANEMAN: Yeah, just to expand on the theme here a little bit. The contrast is industry-based research very focused, not quite incremental, but more innovation-focused. Building upon the current G moving toward the next G. This is-- this discussion was more oriented at the direction of really completely outside of that ecosystem disruptive technology.

[00:25:00.09] So if you go back in time and you think about turbo codes, that was a really fundamental innovation that didn't happen in the context of industry-based research or standardization processes. MIMO, in fact, although it was developed originally at Bell Labs, it wasn't in a standard-setting context when it first hit the street. So investing in the potential disruptive technologies but also really investing in some explorations of potential incentives for spectrum holders to make better uses of spectrum through sharing.

[00:25:33.15] I will say, by the way, that this was actually two of our 11 original recommendations. Neither of which quite hit the threshold for us to include but they-- on their own, but I decided to try to put them together as one recommendation for further discussion here today.

[00:25:48.88] JACKSON MCNEAL: All right. And I believe that it's it.

[00:25:51.60] NICK LANEMAN: That's it.

[00:25:51.83] PETER TENHULA: Great. Well, thank you. Those are great. I actually noticed a little bit of overlap and complementary among the two groups recommendations. Just kind of like in the example, the mission component kind of being mentioned in the context of defining interference, I guess, in group two and efficiency in group one.

[00:26:14.75] NICK LANEMAN: Effectiveness.

[00:26:15.17] PETER TENHULA: And potentially in the various detailed type of analysis or studies that could be done. As in not necessarily as directed by the FCC or NTAA immediately, boy, be bolder and bolder immediately. That was a great recommendation.

[00:26:35.72] But the doing kind of those things as part of that like a legislative package. Say when you're evaluating a band, here's the things you ought to do. And those would be good examples of that. I could see how they fit together.

[00:26:51.86] But those are just my quick observations. I was in the policy wonk group, which is, obviously, that we're mostly policy wonks in group one and looks like a lot of the R&D guys were in group two. So--

[00:27:07.61] DAVID REDL: There's some stylistic differences in the way that the bullets were written up. Right?

[00:27:11.93] PETER TENHULA: Yeah.

[00:27:12.19] [LAUGHTER]

[00:27:12.47] And--

[00:27:12.89] DAVID REDL: Noticed that?

[00:27:14.12] PETER TENHULA: So the endeavor-- the endeavor for writing the report for the students writing reports cross-pollinate these

and then reach out. We'll reach out to everybody that was involved and to review the report.

[00:27:25.55] Before I open it up to questions from the audience and students, I'll just ask you guys if you want to ask each other questions about the recommendations or process. And if there are any overlaps or complementarities you want to potentially highlight.

[00:27:45.59] DAVID REDL: So I have a question for you guys, which is our group took a pretty hard stance that all of the work that is done should be collaborative government, non-government and it seems like your group took a more private sector-led approach. Was that determinative, or did you start there?

[00:28:07.92] NICK LANEMAN: I don't think the intent was private sector-led. Where do you read that?

[00:28:12.90] DAVID REDL: So from the choice of having the private sector do a lot of the testing, I think, is what was part of this. So you have some for the NTI and-- move forward for me, Peter. Do you have it? Thanks.

[00:28:30.42] So I think this is the one where I pursue disruptive technologies and public-private partnerships. I think this is a heavier focus, maybe on the private sector, than we had. Maybe I'm mischaracterizing, in which case, feel free to tell me I'm mischaracterizing. I'm open to that too. But I know that a lot of the back and forth in our group was about how to balance the need for the private sector and the public sector to have a collaborative partnership going forward if this is going to work. Maybe I missed that, and it's entirely possible I did.

[00:29:02.74] NICK LANEMAN: I think that's reflected here in the R&D space to transition. It's one thing to come up with a disruptive technology, whether it's in a government lab, or an academic lab, or even the Bell Labs of the world, it's another thing to transition it. And that's where the industry, the market, the business mechanisms have to pull that technology into the standards. And so some of these pretty innovative public-private partnerships have been making a significant investment, and that's why we brought up the SRC.

[00:29:35.53] In the chip's world materials and devices, they're doing a lot in collaboration with a number of the big foundries and DARPA to fund University research, but each one of these is a slightly different balance. Next G alliance was mentioned, right. That's industry-led, but there's a lot of academics and government participation in that as well. So striking that balance or maybe exploring several different balances is, I think, something that we were hinting at here.

[00:30:08.88] DAVID REDL: Fair enough.

[00:30:09.55] JACKSON MCNEAL: I think that last point talking about incentives that was kind of our-- I'm allowed to anonymously quote participants under Chatham House Rules, right? I think a couple of times it was said like if we try to guess it, we're going to guess wrong.

[00:30:24.26] We're talking about the need for incentives and the need to not like mandate or dictate what the behavior should be with regards to how private forces address interference concerns but how we incentivize them to want to use spectrum more efficiently. And so I think it wasn't reflected as much in our points we presented today, but I think the first part of our discussion had a lot of that discussion of the need to light-- I mean, on a light touch is a very specific phrase, but it's a balance that not overbearing regulatory forces but also how do we push private forces to pursue these ends that I think we all agree need to happen.

[00:31:01.89] PETER TENHULA: And I think in David's group, too, the incentives came up. I think they're implicit in the recommendations in the sense that you get Congress to do that, people will step up and cooperate like they did in the AWS three case, which David mentioned, which I was involved with. And AWS stands for Advanced Wireless Services.

[00:31:25.61] AUDIENCE: Free stand point.

[00:31:26.07] PETER TENHULA: Nick, you have a--

[00:31:26.91] DAVID REDL: What I was to say is I think the underlying premise for us was that the root cause--

[00:31:33.42] PETER TENHULA: Yeah.

[00:31:33.87] DAVID REDL: --of the interference concerns is a failure for people to actually see eye to eye and speak upfront. And then, if you want them to surface those incentives, you have to have people involved in the process. And again, this comes back to the timeline disparities we talked about, which is if Congress sets up a three-year schedule to put together an auction and it takes 2 and 1/2 years to do the studies that are needed to make an informed decision, you're setting everybody up for failure, and you're not going to be able to surface the actual problem.

[00:32:02.86] So it's funny because we-- I think your group took a much more solutions-oriented approach. Like interference is going to happen, how do we fix it? And ours was taking more of a process-based approach to say, OK, how do we stop the problems from starting in the first place? So I think it'll lead to a very interesting report. It was completely unintentional that I think we took those two approaches, but I like that they dovetailed pretty nicely.

[00:32:26.16] NICK LANEMAN: It's the beauty of zero prep.

[00:32:27.84] [LAUGHTER].

[00:32:30.80] PETER TENHULA: And there's obviously life lessons for the students. I mean, this is what happens in the real world. You are told the night before you need to make a presentation the next day. So congratulations on a very successful effort. Nick, do you have any questions for David or Jackson on this group?

[00:32:53.33] NICK LANEMAN: I guess I would be interested to know-- this is me, personally, and I think it's fair to say that a lot of the folks in our breakout. How does R&D policy feed into this broader set of policy matters? I think the-- I've raised this question a few times. There's so many organizations pursuing the development of these technologies and policies.

[00:33:15.32] Coming up with a strategy for the R&D pursuits, I think, is just as important for our future as a number of these more near-term issues that need to be resolved. Because there's a lot-- I hate to say this, there's a lot of potential for duplication of effort and getting everyone communicating and coordinating is hard. And so, it'd be interesting to see from a more policy point of view, how do you incentivize that coordination and strategic research roadmaps.

[00:33:46.52] DAVID REDL: So while we didn't address that in as stark a term as you put it, one of the driving forces for us, as we looked at how this report on feasibility should be done was to force the NTIA and the FCC to go back to their core constituencies. And by making them work and come to a collaborative decision on what the report would like, which we had a very robust discussion about the fact that could result in, essentially, a report that is schizophrenic with two completely differing opinions being presented in the same paper but ultimately going back to Congress with hey, we just don't agree. And part of that is that let's just put the cards on the table. The FCC has a much better relationship with the private sector, and NTIA has a much better relationship with the agencies.

[00:34:27.95] And letting them focus on those individual core competencies talking to their core constituencies about what they're looking at going forward, we think will come out of this more collaborative approach. And PATHSS is one of the ways that we sort of looked at it and said, maybe this is a model for the future. You know DOD has everybody at the table. We have no idea if this is going to work out. It could still collapse spectacularly, but the fact that they're moving in that direction, I think, is potentially a model for how to bring everybody to the table to share what their forward-looking concerns are and also what their present-day concerns are.

[00:35:04.28] But we didn't address specifically R&D issues. I think that just has to be a part of having a process that takes in holistically all of the things that are problematic. And Graham if you have anything to add. That was sort of my take.

[00:35:17.12] GRAHAM STEVENSON: Yeah. I would generally agree. I think the one thing that I would add is a lot of the concerns are that some of the recommendations that we had were born out of concerns that a lot of the collaborative efforts that exist today and have been successful to varying degrees, such as the CSMAC, were ultimately advisory and, actually, bringing in various parties and airing out all of the possible motivations and incentives that are out there in these reports. And as David said, allowing then Congress to choose A or B if they don't agree or having them just come together once everybody's understood where each individual party in each constituency is coming from is the best way to understand exactly what the process needs to do to facilitate the best use, the best development.

[00:36:09.80] DAVID REDL: I think it's also worth noting we acknowledged, and I say this as one of, as I'm looking around, I think maybe two former congressional st-- three former congressional staffers in the room. Congress isn't perfect, right. We get that. They're going to make mistakes, but the reality is we're not going to stop the fact that Congress is going to have a strong role in spectrum policy.

[00:36:30.50] One of our sort of threshold questions or sort of threshold considerations was is it better to have them driving the train or is it better for having them be the court last resort for the aggrieved spectrum user. And ultimately, we said, let's create a process where they're engaged from go-- again, á la the AWS three model-- to try and again keep everybody involved so that-- my former boss Congressman Upton used to tell me all the time, if you want them there on the landing, you've got to have them there on the takeoff. And that was sort of what drove my participation in this conversation is that you need everybody to feel invested in the process.

[00:37:06.16] PETER TENHULA: Right. The group that we were involved in talked about looking at other collaborative models, including what goes on in the International Telecommunications Union, ITU, in preparation for the world radio conferences that was mentioned as a model potentially to follow or not because it does take a very long time.

[00:37:26.84] DAVID REDL: But also, I think what was one of the best comments that sort of led us to the process that we came up with was how the Brits do it.

[00:37:33.94] PETER TENHULA: Yeah.

[00:37:34.36] DAVID REDL: Ofcom makes everybody sit-in a room and hash it out in front of them. And that sort of, like, let's make everybody show their true intentions, show their true challenges was a guiding principle behind how we looked at the process.

[00:37:49.79] PETER TENHULA: OK. We're going to turn it over to the audience for audience questions. And under the wiser rule, the first question goes to a student. Sean if you are in the room where it

happened, if you have any lingering questions, feel free or if you have any colleagues that--

[00:38:07.04] DAVID REDL: The pressure. You thought you got off the hook when Graham got stuck up here.

[00:38:09.38] PETER TENHULA: Yeah.

[00:38:09.68] [LAUGHTER]

[00:38:09.98] If you have a question, right.

[00:38:13.61] AUDIENCE: Well, one interesting thing. David just mentioned he's one of three former congressional staffers, there's one more sitting up there on the other side of the table is, Jackson. I'd be interested to hear what your thought is on the possibility of Congress being the Court of last resort for when NTIA and FCC both make a plan they can't agree on it. They come to Congress, how do you see that playing out?

[00:38:37.62] JACKSON MCNEAL: You know I'm not going to answer that question directly. But while David was talking, I was thinking it was interesting because I don't think that Congress ever came up in either of our sessions in terms of avenues to pursue change. So

[00:38:48.38] [LAUGHTER]

[00:38:50.02] --I think something that David is--

[00:38:52.02] AUDIENCE: It's article one. Come on.

[00:38:53.85] JACKSON MCNEAL: No, no, no. So David is absolutely right, and I think--

[00:38:57.60] AUDIENCE: I'm not going away.

[00:38:59.22] [LAUGHTER]

[00:39:00.12] JACKSON MCNEAL: I just learned it, and they're going to throw it out. Anyway, I think I think that David is identified as something our group did not touch on. Which is that it is smart to get them involved in this process because then, as a court of last resort, it can be a really hazardous place to be in, right.

[00:39:12.09] I mean, they could completely derail the thing you've been trying to do because they simply do not understand what you're trying to do or whatever people are motivating and animating them to make decisions do have them make the right decision. But that's a lot of uncertainty that, I think, by looping them at the start, like David is saying, we can avoid and is probably prudent to avoid. I think so my not answering your question directly is I wouldn't predict, but I think that getting them involved early, as David has mentioned, is the thing that's probably the smarter option to do, particularly-- and I think that kind of goes.

[00:39:41.41] We had some debate about spectrum plan versus strategy and having a national spectrum plan. I think what David's talking about goes more to having a codified national plan. And I think we sort of deviated from that point into more discrete like what are moves we can make to start to have a more uniform-- have more data, make better decisions about how to manage your spectrum strategy. That was roundabout answer that. I never answered your question Sean but you put me on the spot.

[00:40:10.26] PETER TENHULA: Open up. Any other questions? Raise your hand. Hi. Paul, you're on the next panel. You can do whatever you want.

[00:40:20.93] PAUL KOLODZY: I can do whatever I want?

[00:40:22.07] PETER TENHULA: Do whatever you want.

[00:40:23.12] AUDIENCE: Oh dear.

[00:40:23.66] AUDIENCE: Oh, no.

[00:40:25.12] PAUL KOLODZY: So you had one thing on-- for the first panel, you had one not really a recommendation, but an observation and I would be interested to hear a little bit more exposition on when you commented that the timelines are very different between the technology organizations and the policy organizations. But I didn't hear anything that the spare time was both policy-driven and technology-driven are significant contribution to the instant disputes, but then you kind of leave me hanging. It's like, OK.

[00:40:58.21] DAVID REDL: That was by design.

[00:41:00.46] PAUL KOLODZY: That's not a solution. That's a problem--

[00:41:03.52] DAVID REDL: These were findings.

[00:41:03.90] PAUL KOLODZY: --and I was looking for solutions.

[00:41:05.44] DAVID REDL: So this was findings. And frankly, I ended up and, again, I'll out myself. I ended up doing a half-baked primer on CBO scoring processes. And in reality, is--

[00:41:15.55] AUDIENCE: Head of Congressional Budget Office.

[00:41:16.05] DAVID REDL: --head of Congressional Budget Office and how they look at what spectrum is valued at. And it's a wildly unscientific process, but the bottom line is that we see and having drafted a bunch of these and go with Goldman, who's sitting behind you sometimes no matter what you think are the best outcome for a bill based on what you think needs to be done at certain time frames, you have demarcation points at the five year and 10-year mark that are not movable.

[00:41:47.32] And if you put an auction before the five-year mark, it scored differently than if it's in the second five-year window. If you're

doing something beyond the 10-year mark, it doesn't score. And for better or for worse, Congress cares a lot about money.

[00:41:59.48] And so this is kind of the way we were looking at this, which is one of the reasons we said we should do this iterative process. It is much easier to have Congress look at something that's already been analyzed and for which you have buy-in. The number of times I sat with Congressional Budget Office staff and they said, we don't think this will ever happen, so we're basically going to tell you that there's only a 50% chance.

[00:42:25.61] AWS three is a great example. I was told point blank by a CBO staffer at one point AWS three will never be a commercial allocation. Challenge accepted.

[00:42:36.24] We were told very similarly that they didn't think that there would be much spectrum that was derived from the incentive auction process because broadcasters, they want to be broadcasters. Turns out broadcasters won't be broadcasters, so it's cash on the barrelhead and then had some second thoughts.

[00:42:52.02] And so I think these timelines have to be managed in a way that when you are looking at the increasingly difficult challenges we face with trying to pack systems in co-channel. I mean, these are all adjacent channel disputes. I mean, when you're starting to do co-channel challenges, it's going to take research papers, it's going to take testing, and those don't necessarily line up with a five-year window or a 10-year window for congressional scoring.

[00:43:18.36] So our attempt to break those out into pieces do a report, do an auction or do another allocation bill to the FCC later we're our attempt to, essentially, sever those particular challenges. If you want the best example of CBO scoring and weird spectrum outputs, we spent the money from the DTV transition in 1997. We didn't do the DTV transition until the mid-2000. And I don't think I can give you a better example than that.

[00:43:51.55] PETER TENHULA: Any other audience questions. Richard has one. While we're waiting for the mic to get over there, I wanted to just retrospectively if any of the-- if we could turn the clock back and look at, say, two recent interference conflict issues that were, I think, started not in Congress but by either proponents at the FCC or groups of industry, whatever and those ones I'm talking about is C banned and L banned without mentioning any particular parties or agencies. What if any of these recommendations you think could have helped in avoiding, let's say, avoiding instead, of resolving, avoiding those interference conflicts in L or C band or any other letter band do you want to talk about?

[00:44:45.89] DAVID REDL: I--

[00:44:46.32] PETER TENHULA: If that's too challenging a question, then--

[00:44:48.42] DAVID REDL: I was inside--

[00:44:49.37] PETER TENHULA: --be sure to punt.

[00:44:49.77] DAVID REDL: --on all of those decisions.

[00:44:51.25] PETER TENHULA: Yeah. Yeah.

[00:44:51.61] DAVID REDL: I'm probably not going to comment that.

[00:44:53.60] PETER TENHULA: OK. Recused. Right. You guys may not know enough about those conflicts, but maybe Preston can figure out a way how to-- if we had these kind of mechanisms in place but Richard has the next question, then maybe Preston.

[00:45:14.73] AUDIENCE: Keep it brief. It's more of an observation than a question. It seems like. David's group was about how do we manage the conflicts that come up in the context of the technology that we have today and through Congress. And when you understand, the more I understand about how Congress addresses these issues, the more convinced I become that we want to minimize the Congressional role as much as we possibly can.

[00:45:43.31] And so the second group is about how do we develop new technologies that make spectrum coexistence more seamless and essentially enable us to supply the ever-increasing demands for spectrum by innovative new applications and services by making our use of spectrum-- by making spectrum coexistence more effective. And I mean, I noticed that the aviation industry wants to codify the temporary rules under which the airports have been operating since the rollout of C-band and that's exactly the kind of thing we want to avoid. I mean, that would be a disaster.

[00:46:33.76] There's so much money that's been invested in the use of C-band by 5G, that to allow these legacy systems that have been in the field for 40 years to continue to squat. Sorry, Preston, I'm in your script here. Yeah, that'd be horrible. And we want to avoid outcomes like that and I think, as a technologist, I can't help but believe that, I made the right decision to spend the last 40 years working out networking technologies because that's really the only place the answers are going to come from long term.

[00:47:07.65] PETER TENHULA: Your question, please?

[00:47:10.04] [LAUGHTER]

[00:47:10.52] AUDIENCE: What do you think about that?

[00:47:11.81] PETER TENHULA: What do you think about that?

[00:47:12.83] [LAUGHTER]

[00:47:15.24] DAVID REDL: I mean, I'll give the law professor answer, right, if I were teaching this as a course. You can't write Congress out of it. It's literally unconstitutional.

[00:47:24.26] So to say, yes, we want to minimize the Congressional, I'm not sure you actually do. Believe it or not, Congress has played a pretty decent role in moving things forward. We actually, in our group, had a very brief discussion. Should Congress stop reauthorizing spectrum auction authority, should they just make it perpetual?

[00:47:46.31] Not surprisingly, incumbent users said absolutely not, and potential new users or potential auction participants said, of course, yes. Give it all to the FCC. In reality, even if you did that, it's not going to stop Congress being involved. It's going to continue to happen. Because members of Congress are always going to have constituent interests, macro-political interests, macroeconomic interests, and making sure the United States is moving forward.

[00:48:14.51] Arguably one of the biggest drivers right now of spectrum policy and of tech and telecom policy in Congress is the desire to be ahead of China in every aspect of technology. And if you think you're going to take that national security question away from, Congress, I think we're kidding ourselves.

[00:48:34.77] GRAHAM STEVENSON: I can add one thing to that as well. One of the things that I think our group implicitly recognized to David's point about not being able to take Congress out of the equation is that regardless of where you want Congress to be involved, there's an overlap in the constituencies between the FCC, NTIA and both of those feeding into Congress. Whereas if FCC and NTIA are not interacting with their constituents directly, then those constituents might just run to Congress. And as we've talked about Congress doesn't always have the most expertise in a lot of these issues. And so, having those agencies involved in the report process that we came up with can help alleviate some of those concerns to an extent.

[00:49:19.82] DAVID REDL: Yeah. I'm gonna give you one last word, then I'll pan over to you. Having spent time drafting spectrum legislation, I will tell you every committee in Congress thinks that their agency's spectrum is in their jurisdiction, and it is not. And so those inter-jurisdictional fights in Congress, while they can be incredibly frustrating when you are a Hill staffer or incredibly frustrating when you're fighting report language in a Defense Authorization or appropriations rider language, they play a pivotal role in actually driving things forward.

[00:49:50.87] Just as we said, we need to surface more of these things early, for better or for worse, the Congressional appropriations and authorization processes surface problems. They don't always solve them, but they for sure surface them.

[00:50:03.92] NICK LANEMAN: Yeah, I was just going to react to your comment. I don't necessarily see it the strategy being that we should try to reduce the role of Congress or other policymakers. In fact, in Spectrum X, for example, we're not actually allowed-- NSF is not allowed to do any policy advocacy. What we can do is engage with policymakers and inform them, understand the things that they want to understand better and then try to provide them with data, provide them with insights, provide them with trends. So helping inform them so that they can make better policy is, I think, the right strategy.

[00:50:40.44] AUDIENCE: I was more about-- to assume that we've reduced the importance of what they're doing just to make their job easier by giving them better tools to reinforce.

[00:50:52.55] AUDIENCE: Technology, so right? Right.

[00:50:56.14] AUDIENCE: Yeah, I kind of have--

[00:50:57.64] NICK LANEMAN: Pardon, I should say.

[00:50:58.66] AUDIENCE: --an issue thinking about the notion that Mehmet Oz and Herschel Walker are the answer--

[00:51:02.50] [LAUGHTER].

[00:51:05.75] --but what I worry about is the integrity of the FCC spectrum allocation process. If you look at what has happened to AT&T and Verizon, the FCC said we're going to hold this auction, and nothing was said about having to protect the aviation community hundreds of megahertz away. And these two American companies bid in good faith $82 billion, and as Richard just said, now the aviation community wants to codify what we're supposed to be temporary restrictions on the use of their spectrum. And you couple that with DOD and the legato problem, and I begin to worry whether anybody's going to believe the FCC in the future when they say, show up for an auction, we have spectrum to auction for you.

[00:52:06.68] DAVID REDL: I mean, I'm not going to comment on those particular challenges. But I will say that the spirit of our recommendations that you need to have everybody at the table as early as possible, I think, is in the spirit of trying to solve those very complicated problems. It's not directly on point to either of them, and I do not intend to comment on either of them, but our overarching goal was to have everybody at the table as soon as possible again, to surface problems as early as possible and solve them as early as possible. That was what drove us, and we were very thoughtful about not having conversations about specific challenges and instead looking holistically at the process.

[00:52:47.77] NICK LANEMAN: I'll just maybe jump in. Regarding your question, Peter, I think if there was more testing earlier on in the process if there was a better understanding of the population of

receivers that are out there that perhaps some of the ground truth could be better established instead of a lot of conflicting reports.

[00:53:12.22] PETER TENHULA: Conflicting reports. And there was talk in one of the panels, I think it was the first panel yesterday, about the ultimate arbiter right. And some say it's the White House, some say is it courts, is it the Congress here it's like so-- that raises interesting questions about then what, right.

[00:53:34.79] It seems like a lot of these suggestions are about well Congress be involved. By implication does that mean not the White House but the answer, I guess, is no because the White House gets involved in actually recommending legislation right. And has in the past White House was involved in--

[00:53:57.01] DAVID REDL: You never know who's going to have the last word until they have the last word.

[00:53:58.63] PETER TENHULA: The jobs aren't, right?

[00:53:59.35] DAVID REDL: I mean, the answer to that is if I had my magic eight ball, I'd turned over to say ask again later, right.

[00:54:03.02] PETER TENHULA: Right.

[00:54:03.38] [LAUGHTER]

[00:54:03.50] DAVID REDL: I mean, you don't know until you're in the situation. Every one of these is different. Sometimes the courts settle it, right?

[00:54:09.58] GRAHAM STEVENSON: Right.

[00:54:10.46] DAVID REDL: Sometimes the White House intervenes, sometimes Congress does. But, again, like if your overarching goal is to-- first of all, I think we should-- one overarching goal we didn't talk about but should be to keep these things out of courts. If you're doing the hard work up front, you're keeping these things out of courts. So we can put our friends in Article III to the side for a moment.

[00:54:28.75] AUDIENCE: [INAUDIBLE].

[00:54:29.63] DAVID REDL: You know, but the executive branch and the legislative branch, in cooperation with all of the people who are both users and want to be users, should be able, if they are working this problem in an appropriate timeline in an appropriate manner surface and solve problems. The issue comes when, again, those timelines or those incentives either don't line up or aren't surfaced early enough.

[00:54:52.05] PETER TENHULA: Any more? One burning more-- one more question here, and then we'll--

[00:54:56.58] AUDIENCE: So-- this is for David, I guess. The aspirational goal of having everybody at the table from the get-go is-- doesn't

reflect the notion that sitting at the table or participating at the table is incredibly expensive. And in your quest to do that, have you considered anything about how you might put a process or an environment in place that allows people to be at the table that aren't only the big pockets players?

[00:55:28.73] DAVID REDL: So we did not explicitly consider that. I will say it costs almost nothing to file comments in ECFS. Anybody that has a laptop can write comments and send them to the FCC. So if you--

[00:55:40.14] AUDIENCE: Comment on--

[00:55:41.60] DAVID REDL: So the public participation process in both the FCC, and frankly when NTIA puts things out for comment as well, there's a pretty low financial barrier to entry to participate in SS, at least at that level. I hear what you're saying. It's not like people can pick up and travel to Washington every week to sit in meetings. You can't dedicate your entire day to being on Zoom calls with people, I appreciate that.

[00:56:04.22] But I think there are certainly varying degrees of participation depending on, frankly, how badly it's going to impact you potentially if it goes sideways. And frankly, we see that already. The people that are going to be impacted positively or negatively the most are going to be the loudest. That's already the status quo.

[00:56:27.61] PETER TENHULA: Well, thank you. After a short 15-minute break, we're going to come back for our final panel, on which four of the breakout session discussants are going to give their thoughts and concerns, examples or even dissenting views, if there are any, about the recommendations that were just revealed here in this panel. So please join me in thanking our very hardworking--

[00:56:52.43] [APPLAUSE]

[00:56:54.54] PETER TENHULA: --people here.

Conference Wrap-Up

https://www.youtube.com/watch?v=v4lG1Q4TwI8&list=PLTAvIPZGMUXPndAsSb8280szXsRO0E_HU&index=6

[00:00:00.30] KEITH: OK, everybody, let's resume our seats and get going with our final panel of the day. But we'll get to discuss some of the thoughts and issues and potential outcomes of the recommendations that we had. So our moderator for this panel is Anna Gomez, who is a member of our Silicon Flatirons advisory board. And she introduced herself as a retired telecommunications attorney, so I'll go with that.

[00:00:28.41] [LAUGHING]

[00:00:31.03] ANNA GOMEZ: Thank you, Keith. Yes, I am happily retired. So I get to just observe, I don't have any agenda here other than to try to be a good moderator. So good-- good morning-- wait, what time is it? Good morning. This is our last session, we are going to do a wrap up in which our speakers are going to give their reactions to the recommendations that you just heard in the last panel. So I'm hoping this will be dynamic and not heated.

[00:01:07.02] But so first thing I'd like to do is to ask each of them, since these speakers were pulled out from the breakout sessions, their bios are not online. So I wanted to ask each of them to just give us a little bit-- I know you know most of them if not all of them-- but give us a very short discussion of your background. And I'll start with you, Julius Knapp, who nobody knows.

[00:01:29.42] JULIUS KNAPP: Yeah.

[00:01:29.85] [LAUGHING]

[00:01:32.13] I'll keep it short. So I was at the FCC straight out of college for close to 46 years. The last 14 of them-- close to 14-- as chief of the Office of Engineering Technologies. Spent almost my entire career at one dimension or another on spectrum. Had the perspective from working with actual products at our laboratory and so many spectrum disputes over the years, and hopefully, can share some of the insights from that experience with folks. I retired, it's coming up on three years ago. Golf did not serve me well.

[00:02:20.34] [LAUGHS]

[00:02:23.38] And so I've deliberately not taken on any job, and just trying to help out in some of what I'll call academic areas [INAUDIBLE] like this is how can we, where we've run into some problems, how can we make things work a little better?

[00:02:41.21] ANNA GOMEZ: Thank you. Jonathan.

[00:02:44.26] JONATHAN WILLIAMS: OK. Yeah it works. Hi, morning. My name is Jonathan Williams. I'm a program director and spectrum

manager at the National Science Foundation. I've been there for about five years now. Before that, I was at NTIA for about 14. This is a second career for me.

[00:03:03.30] I also went straight into spectrum management from college for electrical engineering. Before that, I was in psychology doing about what you could do with a bachelor's in psychology. But I often find that that experience is unexpectedly relevant in spectrum management.

[00:03:20.42] But a lot of what we do in the NSF is what you think of traditionally as spectrum management but an awful lot of it is related to NSF's core purpose, which is funding research and development. And you've heard some of what we've been doing a little bit in the last couple of days. And we're not done, we're still working on some other ideas.

[00:03:43.23] ANNA GOMEZ: Great. David.

[00:03:44.61] DAVID GOLDMAN: Hi, I'm David Goldman. I'm a little superfluous because I'm not sure I know anything about spectrum I didn't learn from Julie in the first place.

[00:03:53.26] [LAUGHING]

[00:03:54.25] So I will spend my time repeating and underlining what Julius has said. I work at SpaceX. I've been here for 4 and 1/2 years now. Before that, I've worked in the FCC house in the Senate. My previous job was I was in the House of Representatives. I was actually Redl's counterpart, I was a Democratic counterpart. So just imagine what that was like.

[00:04:17.16] [LAUGHING]

[00:04:19.73] I see he's not in here. When he comes back in here, I will apologize, I'm going to repeat that again for him.

[00:04:24.50] [LAUGHING]

[00:04:26.30] But yeah.

[00:04:28.73] PAUL KOLODZY: Paul Kolodzy, I've been a technologist my entire life, a lot of it in the communications and electronic warfare, so counter communications lifespan. I spent a lot of time in MIT Lincoln Laboratory, and I was [INAUDIBLE] at DARPA for a stint. I was also at the FCC as a senior spectrum policy advisor. We ran the Spectrum Policy Task Force a few years ago. And since then, I've actually been an independent consultant on a variety of areas, most of them actually helping out the Defense Department in their advanced technology.

[00:05:06.92] As a little of a side note, this month is the 20th anniversary of the Spectrum Policy Task Force. In fact, what is it Peter was just reminding me, Peter Tenhula, that literally on the 30 of this month will

be exactly 20 years that we were here in Boulder actually giving the release of that document. And actually we were joking about how we were actually putting together the briefing in the hotel room with Chairman Powell at the time, that morning before he actually gave the presentation.

[00:05:35.43] One of the things actually to note I think would be relevant for this discussion is what happens to recommendations? And I think you need to think about is actually the receptiveness of the audience is actually the most important part of recommendations. You can espouse as many things. We had a lot of good recommendations. And I think Julie and a lot of other people will actually comment that over the decades, about the different processes that are going on in recommendations.

[00:06:01.52] When we take a look at recommendation, we need to look at the audience we're trying to actually hit and how that-- so we have some great ones but not many of them have been acted upon. And now we're here 20 years later, and we'll have to ask the question, what are going to happen with these recommendations? And with that, I'll pass it to Anna.

[00:06:15.86] ANNA GOMEZ: Oh, you stole one of my questions. Thanks a lot.

[00:06:17.72] [LAUGHING]

[00:06:19.45] So just a reminder, as Peter mentioned earlier, the breakout sessions were conducted using the Chatham House no attributions rule. So while you can use the discussions, please do not attribute them to any individual participants or you will be severely disappointing Dale Hatfield, which is one of the worst outcomes you can imagine.

[00:06:38.54] [LAUGHING]

[00:06:43.46] So first of all, can I just ask you to give us your general thoughts about what you just saw? And Paul, I'll start with you, since I started with Julie the last time.

[00:06:56.11] PAUL KOLODZY: So what I just saw-- and I'm going to start off with a high note but then also end with a little bit of a low note just as a starting point. Actually, first of all, we had some interesting groups that got together. And I think we have some interesting takeaways in some sense, not recommendations but takeaways, commenting about how conflicts are actually not between current users, but many of them is between incumbents and/or want-to-be incumbents and end users.

[00:07:24.87] And also-- but I actually think that whole issue comes up to showing that Julie, I think over those years, you guys did a great job,

meaning when you put the rules together, the people actually started working together. Worked pretty well.

[00:07:35.28] And the second thing we found out was like disparate timelines and that, kind of, commentary about how technology timelines are faster. In those respect, I think we did a very, very good job, and the groups did a very good job. I think on a flip side of it is I'm trying to figure out what the audience that you're actually trying to reach with some of these recommendations. It was extremely confusing as to what messages were you trying to put out there.

[00:07:59.17] And I think that some of the things that you need to be thinking about when you're trying to put some things together, what are you trying to what message are you trying to give and why are you trying to give it? And what would you do? Are these recommendations the same ones that you would have had 20 years ago, 30 years ago, 40 years ago? Is that really moving the ball forward or is that basically saying, Yes, we got problems, or, we knew we have problems.

[00:08:22.16] ANNA GOMEZ: Well, I suppose to a certain extent, it's about incrementalism, right?

[00:08:26.20] PAUL KOLODZY: Yeah.

[00:08:26.87] ANNA GOMEZ: Because you're not going to solve everything in one day. So we talked about this question earlier about the audience for the recommendations. So I went out and I looked up the description of this conference. And I felt like it was-- the audience is all the stakeholders because what it says is, following up on the roundtable discussion, the full spectrum conference will take a deeper dive into the prevalent tensions that characterize interference disputes, how they came about, why they have been exacerbated, and what could have been done to prevent them, what technologies or standards may have helped resolve recurring issues, and what realistic and actionable solutions should be pursued. So it is broad.

[00:09:12.48] And maybe, one of the things that we can get out of this is, well, maybe, we need additional discussions that break out the categories so that we can think about really, how to make it implementable. But anyway, that was just my thought on that. David, would you like to pick up.

[00:09:29.71] DAVID GOLDMAN: Yeah. So I guess I struggle a little bit with these recommendations and looking at them because I've had experience working on various perspectives on spectrum policy. But what I've been working on for the past few years has been in satellite spectrum. And it's looking at a lot at what these recommendations were, I feel like I live in a parallel universe.

[00:09:56.32] The idea that the first thing that comes out is that there's no problems for existing users is just look at any docket that's going on that frankly, that I'm involved in, any of the space dockets, it's all fights

among existing users about interference. And it actually goes to show there's a lot of spectrum that satellites have allocated to it in the higher bands, but it's a fair bit of spectrum.

[00:10:24.16] And I'm guessing, we have some of the smartest spectrum people in the world sitting in this room. I bet most of you don't actually know what the rules are for that spectrum. And I'll tell you what a lot of it is, is that it's a cage match. It's shared spectrum, and I know everyone's like saying, we like shared spectrum, that's great, I like shared spectrum, we should be going to more shared spectrum.

[00:10:46.78] The rules for most the satellite stuff, at least for the non-geostationary orbit satellites, the next generation ones that we have, the rules for most of it is, you guys share it and you guys figure out how you're going to do it yourself. And there is no other rule-- oh, and when you get in this fight, do it in good faith. That's it.

[00:11:06.18] And so these are really tough battles. And so I mean, I'm talking about this one because it just struck me out of the gate kind of reading through these of like, even the very first one, I don't think actually applies to a lot of spectrum. But as I look through a lot of this, I think that there's a lot of fighting the last war that's going on. I know we're saying this isn't a specific thing, but I also know every one of these things, you can go through and you know people were thinking about, you know what fight they were talking about when they came up with these bullet points.

[00:11:39.20] And I-- but just looking ahead and, again, just talking about the stuff that I'm working on because it's stuff I know best, it's we now have deals with wireless carriers as a satellite operator, where we're going to have heterogeneous systems where they're working together, and the difference between satellite and terrestrial is going away. We have federal customers, I know we heard about how DOD is going to use 5G and commercial 5G, same thing is happening on the satellite side. I have federal users who are-- the DOD and other agencies are looking at how do you leverage commercial satellite more?

[00:12:12.65] The lines that are the traditional lines that we're used to fighting from the last decade, if I'm guessing, those things are getting wiped out. I think that if I look ahead, I think a lot of these battle lines that we think exist, I think if we come back in 10 years, we're going to look back and say, yeah, those were the old days, and that's not what we're talking about anymore.

[00:12:30.08] And I just-- so when I look through all of the recommendations, I'm a little worried that we're not actually looking out into the future. I know it was mentioned on the previous panel but I was a big advocate, I continue to be a big advocate. I think what we should be thinking about is how are we setting the right incentives for people to be doing the right things, rather than prescriptive descriptions of what we should do because I think prescriptive, we're going to get

them wrong. That's the lesson, you look back and we get it wrong every time, we try to guess.

[00:13:03.65] But I think if you try to set up the right environment for people to act the right way and set up incentives, again, in the cage match in the satellite world, if you set a cage match, the incentives are all backwards, right? Like, start thinking about what everyone wants to do in that world and it's the exact opposite of what all of us say that we want them to do. I think we need to think more about how do we set up the right incentives going forward. And I'm a little worried that these recommendations don't quite get there. There's a little bit in there, but just overall, I'm not sure it quite gets there.

[00:13:32.48] ANNA GOMEZ: That was a long discussion, well, seemed long to me. And I think it was-- I forget which one was Breakout A and Breakout B, the innovation breakout group talked about time frames and how do we see the future. And pretty much, the decision was we can't. So we have to start from somewhere. But I hear you on how do we make it so that it's future proof? Anyway, Jonathan.

[00:14:01.45] JONATHAN WILLIAMS: Yeah, so it's very interesting. When I was going through these summary bullet points, my first impression, especially as they were discussed by the moderators, was I felt that they were pretty fair. I thought that they seemed to capture a lot of the discussion. I think David is right regarding this particular point.

[00:14:27.80] DAVID GOLDMAN: I agree with that point.

[00:14:28.67] JONATHAN WILLIAMS: Yeah. And it's interesting because it's not just the satellite world where things can be so cutthroat, they have their own agenda item dedicated to them at every world radio communication conference. It's a conference within a conference, it is that challenging to coordinate these things. And it is an ongoing issue. The problems are not solved, the problems are being identified, they try to fix something and a new problem pops up.

[00:14:57.23] One of the things that I thought was really interesting, and I mentioned this during the break, was I almost wish that the two breakout panels yesterday during the break had kind of cross-pollinated their ideas because they're really not mutually exclusive. The idea that you need to work on the process and fix the process cannot be divorced from further developments in spectrum, how we use spectrum, innovations in that. The one informs the other and the other informs the one.

[00:15:30.23] So I think that maybe there could have been some additional thinking and additional results coming from that. But by and large, I thought that there was a lot of good material captured and I, like I said, I really like the discussion coming from that as it was described.

[00:15:48.44] ANNA GOMEZ: Great, thank you.

[00:15:51.46] JULIUS KNAPP: What was the question?

[00:15:53.08] [LAUGHING]

[00:15:54.43] ANNA GOMEZ: What are your reactions, generally?

[00:15:56.62] JULIUS KNAPP: Just generally. So first of all, for Graham and Jackson and the students here, getting insight into what you're going to be doing tomorrow at night is a long lead time.

[00:16:10.54] [LAUGHING]

[00:16:13.21] Fine, we're going to put you on a panel and you'll react to what they're going to say.

[00:16:17.86] [LAUGHING]

[00:16:20.14] ANNA GOMEZ: An hour later.

[00:16:20.83] JULIUS KNAPP: Yeah. No, not even 15 minutes.

[00:16:22.99] ANNA GOMEZ: 15 minutes at best.

[00:16:25.21] JULIUS KNAPP: So just at a high level, I thought group one and David kind of characterized this. I don't see David in the room if he's back.

[00:16:34.42] ANNA GOMEZ: David's not in here, in case anybody has noticed.

[00:16:36.88] JULIUS KNAPP: Yeah.

[00:16:37.14] [LAUGHING]

[00:16:38.52] SPEAKER: OK, you can say anything you want then. So I think generally, the first group focused more on process. How do we make the system work better? And I think David's point, which applies to both is forward-looking. Not just taking the stuff from the past. But kind of, "Look, hey, David, I'm giving your credit for your work, just like you told me to."

[00:17:07.00] [LAUGHING]

[00:17:10.75] JULIUS KNAPP: No, no, no. No, and I'll elaborate a little later on that. I thought they were on the right track. Maybe it seemed to me that on the whole, what's needed is a little more specifics.

[00:17:26.65] You know, what exactly would you do? And it has some thoughts on that after. And the second, more or less the same thing. It was focused more on solutions. Technical solutions and so forth.

[00:17:40.88] And I think part of the struggle is we threw a lot of things out there, but where do you take them? How do you focus it? So you're taking that work.

[00:17:54.44] On the one hand, there's always basic research. You don't know how something is going to be used, which is a good thing too. On the other, it's like can you see problems coming down the road? And what would you be doing now that would help to avert or at least better understand those things?

[00:18:14.10] The one thing I will also say about process across the board, because I think this isn't just on-- we talk a lot about FCC and NTIA, but for the community it's like nobody understands me. Any particular service. They don't understand what I do, how important it is and so forth.

[00:18:34.47] So it does seem like there's a gap in the education across the community of-- Because I think sometimes we were just talking about this earlier. It's like everybody ought to know what I do and they don't.

[00:18:53.54] And outside of the particular conflict, just having sessions that-- And I'm not sure where the right forum is. Maybe it's something joining the FCC, NTIA sponsor come in and we're going to do a session that explains here's what's going on in radio astronomy or here's how the Department of Defense sees 5G and its role and where it's going and so forth. So those are just some thoughts on how.

[00:19:22.24] ANNA GOMEZ: Yeah, that's a really interesting idea. I think identifying the conflict earlier is-- it can be a challenge because some of these conflicts have arisen in spectrum that shouldn't have been impacted.

[00:19:36.29] JULIUS KNAPP: Yeah.

[00:19:36.68] ANNA GOMEZ: Right, we talked about this yesterday. And so how does somebody sit up and go, wait a minute, this is going to affect me without knowing it's actually going to do it.

[00:19:48.77] JULIUS KNAPP: So I'll just-- we'll try to just keep talking. But so we have all these examples of things that didn't go well. But there are far more examples of things that you may not have liked the outcome, where we got out of head of it collectively.

[00:20:12.41] And the thing that stands out to me, and it's not the only one, and nor am I going to suggest this is the model to apply everywhere. But CBRS. So that didn't come out of the blue. A lot of folks forget about all of the work that had gone on for 12, 15 years before, looking at things like STRs and how we can do smart sharing and so forth.

[00:20:35.55] And there were a bunch of things that were not highly successful but they laid the foundation for this. And what was remarkable about it was we had military systems that had to be protected. And working through how is that going to work took time.

We had the unlicensed community, which was like we want to be able to have access to this.

[00:21:03.05] In the commercial community, which felt, well, wouldn't it be better if we can just get everybody out of there and auction it that-- we get it that sometimes those things can work or not. But the fact that you had all of these folks coming together to work out the problems, and it took time. Because I remember at different stages where folks were saying, "Well, where's the NPRM? Where's the reporting order?"

[00:21:31.58] And we're like, "Hold on. We're talking with NTIA, we're talking with the-- They've got some concerns. We're trying to figure out how we solve these as opposed to let's throw it out there and then try, which makes it really harder to solve things. So I think just generally, across the board, taking some of those lessons learned and how do we get the out of ahead of the information? How do we get out ahead in trying to solve the problems before everybody has had the arguments devolved to, "I'm more important than they are?"

[00:22:14.07] ANNA GOMEZ: Yeah. I think a lot about the c-band example. I hate to raise it. But if we'd known earlier, and I'm not saying-- Jennifer Warren's not even here so she won't jump down my throat. But I'm not saying that people did not participate early on. But I am saying that people did not try to find solutions until very late.

[00:22:36.69] And if that had been done prior to the auction, it would have been a very different dynamic. But I come back to Paul's point in his opening statement. How do we incentivize?

[00:22:53.52] How do we give the incentives to the stakeholders to cooperate when our first reaction is, I'm too busy. I don't have the resources. My engineers are doing other things. It's not my mission. I'm not going to help you take my spectrum.

[00:23:08.43] I'm not going to help you possibly interfere against me. How do we give those incentives? And I don't know who to talk to about this. Actually, Jonathan, since you have such a broad background in both science and NTIA and psychology.

[00:23:26.80] JONATHAN WILLIAMS: So I could reach back to behaviorism. But I don't think I want to go that road with rewards and punishments. It's interesting because Julie made a very good point. One of the things that we see a lot in spectrum is we need a lot of work on workforce development.

[00:23:44.74] So a lot of places are stealing from each other constantly when it comes to people. So you'd think that people would have a really holistic view of where other people are coming from. And it oftentimes just doesn't work that way in practice. I know when it comes to what we try to do, we're kind of the little kid on the block a lot of times.

[00:24:04.50] We're not the best staff. We're not the biggest agency out there. And radio astronomy, a lot of times is seen as more of a hindrance than a use of the spectrum that really is revenue generating or something like that. So a lot of times we end up working with people out of necessity.

[00:24:27.00] We start with partnerships early on and we found that to be very fruitful. But as far as we're concerned, we also have, as part of our mission, trying to support the advance of science and the useful arts across the board. It's not just radio astronomy. So we have as part of our mission to do this and that is an incentive for us.

[00:24:49.83] I fully understand, however, where people are coming from, where they don't have enough time in the day. They don't have the people, even the best staffed agencies run into this on the federal government side. So how do you create incentives? I think the number one thing is to make it easier for people to work together. Make sure that the process is constructed such that everybody knows that they're going to be listened to.

[00:25:16.87] They may not get what they want but they're going to be heard. And I think there are a number of other steps that I've seen taking place recently, that I see as very positive, that are helping that process. But I think the incentives are going to be different for every stakeholder, public and private.

[00:25:37.23] ANNA GOMEZ: OK.

[00:25:37.67] DAVID GOLDMAN: Yeah, I think that's right. But no one wants to go into anything where their only outcome is loss. And so like you're saying, you listed all the reasons why people don't want to show up. And those are real, right?

[00:25:50.57] Like if you have a business, if you're a government agency and you're running. And you have an existing mission and you're trying to get that done and that's the most important thing you're doing. And you're saying, you're told, "Come in now for a process to sit down. And if you interact with us and do everything really well, we won't hurt you that much."

[00:26:08.33] [LAUGHING]

[00:26:10.38] Right. Like who wants to-- No one wants to go to that party. So I think there needs to be, I think on the incentive side, I actually think we need to think a little bit more creatively about what incentives could be. There could be financial because there is a lot of money going on.

[00:26:24.06] And at some point, especially if we really do think that the existing use somewhere is not the highest and best use, potentially there's money involved in the delta there, of putting it to the highest and best use. And we do it with the incentive auctions, there's the-- but

there could be other financial ways of doing it. I know with government agencies, one of the big problems we have in the government agency is the money always comes after the auction but they're asked to clear before that.

[00:26:48.83] And if you could somehow come up with a procedure where they get the financial compensation, possibly more than just, you get kind of similar equipment to be replaced. But something where you get better equipment. And the money-- I'm not saying this is easy, but somehow, the money gets there before rather than after.

[00:27:06.77] I think then you start getting people to say, oh, there's actually something in it for me if I do this. I think we could think about whether there's regulatory benefits you can get. Do you get some sort of favored treatment and some sort of regulatory proceedings if you're a good actor coming to the table on a lot of these things. But I think so long as, and so much so many times, basically the only thing we're ever asking anyone to do is come to the table so we don't hurt you as bad.

[00:27:30.65] It's just, I think that it's going to be very hard to get a lot of participation in that. I think you've got to think more creatively about what putting something on the table so that everybody gets something out of it.

[00:27:43.46] PAUL KOLODZY: Kind of piling on that but from a very different technical perspective versus the incentive perspective. Individuals or organizations are trying to do optimization for themselves. This is basically the simple thing of local optimization versus global optimization.

[00:27:58.25] So what does the country try to do? The country tries to globally optimize because that's what their goal is. Companies want to locally optimize. Why? Because that's where their perspectives are coming from.

[00:28:07.50] And so now the question is, how do you actually balance those two areas out? So it's not just the process of just everybody saying, well, what can the global give to the local? What can each of the locals-- But it is in some sense, if you look in a technical way, it's actually a difference between local optimization and global optimization, and that is there are basically, what are you trying to optimize?

[00:28:27.08] Actually, I think that's one of the things I actually did like with one of the recommendations that were coming out there. Which actually is trying to look at the exact words where I keep going down.

[00:28:39.59] No, I keep going on to this, tada, tada. Keep going. It is basically looking at the frameworks. Well, actually one more slide. Sorry.

[00:28:53.22] ANNA GOMEZ: OK.

[00:28:54.12] PAUL KOLODZY: Assess and characterize, I mean, here it is. Embrace risk informed versus worst case interference analysis, including economic factors. So basically looking at the whole circle around systems. What is the cost of remediation? What are the costs of all these things?

[00:29:08.58] You're doing local optimization but you have connectivity between them. Think like someone, like an engineer in some respect, and ask the questions. What are those kind of activities that need to occur? And what are the kind of controls do you actually have?

[00:29:20.91] We tend to talk about these in the abstract, and I'm just asking the question is, do you start looking at this in a sort of more hard mathematical science in the sense of trying to figure out how you do those local and global optimizations? And I just get tired of it because of everybody that comes in from the perspective of being locally optimized, right? They just want to optimize what they need and that's all they need to have.

[00:29:41.86] So I think a different perspective needs to be taken here. And ask the question, how do you actually start studying that? That's actually a great studying problem, is in a sense of actually asking for the students. How do you look at those local optimizations versus global optimization issues?

[00:29:58.49] ANNA GOMEZ: Just looking at our folks from silicone flat irons. Maybe that's a good topic for future conferences and papers. You made me think about recommendation for embrace risk informed over worst case interference analysis. And how does that interact with develop a framework for harmful interference that includes mission impact and technology impact?

[00:30:23.60] I guess the framework is sort of the-- here's how we're going to look at it. And then the risk-based is, and using--

[00:30:29.48] PAUL KOLODZY: One specific issue.

[00:30:30.65] ANNA GOMEZ: Yeah, well for case by case analysis. We'll do it this way. That makes a lot of sense. I mean Tom and I were talking in the car about risk-based interference analyzes and the different case scenarios where there's a high risk in some cases. And then in other cases, it's actually pretty low, except for maybe economic.

[00:30:50.85] So I think-- and it made me think of peer because he was so into risk-based regulations. But I really like that particular recommendation for a variety of reasons. Let's really think about how serious the consequences are.

[00:31:11.64] PAUL KOLODZY: Can I ask something, also to think about when you're looking at the risk-based. And now, I'll talk about-- So I sort of disagree with you about incremental approaches, which is try to

actually go a little bigger. Go bolder and bolder, I keep hearing. So let's talk about that for a second.

[00:31:28.08] And again, this is ad hoc here. So I'm just kind of swinging a little bit.

[00:31:31.30] ANNA GOMEZ: But we are doing now.

[00:31:32.49] PAUL KOLODZY: OK. So this is-- What we don't ask the question as to what has actually changed with spectrum. And for the first, not first time. For about the last 30 or 40 years, the concentration of how spectrum is being used. So if you look at risk-based assessment, if you're the only avenue for use of a spectrum for a particular application, a particular area, let's say rural, you may have particular type of rules versus what's going on in the urban where there's also a multiplicity of issues.

[00:32:05.22] Also you can flip it around, which is they need a lot more in urban versus they don't need it, maybe they don't need as much in rural. So the question becomes, are the rules-- I'll be bolder. Are the rules actually needing to now start getting more bifurcated? In a sense of what is meant by interference in the sense of certain environments?

[00:32:25.38] Is the space environment different than the rural environment, which is different than the urban environment, which is different in other environments? Right now we try to mash it all together as much as we can, and trying to build the rules up that are kind of equitable across. And the argument used to be because the equipment can only be built one way. But we now know equipment doesn't have to be built that way.

[00:32:47.73] We are building, basically, we are close to it actually. We have now a trillion transistors, I think, is now being played around with in a sense, some individual devices.

[00:32:57.28] So when technology is coming along, can we start looking at this as a different way? Is there a different way? A potential for alleviating some of these interference issues? Just a bold thought.

[00:33:09.36] JULIUS KNAPP: So I think the good recommendation, and I'll just kind of come at it from a few different perspectives. One is how do you translate it into applying it to a given situation? That's always the difficulty. Because the eye of the beholder may be completely different as to what the risk is and what the consequences are if something goes awry.

[00:33:40.80] And I think we struggle at times with, well, interference could occur if these 10 things all aligned. But we think it's highly unlikely. Well, first of all, we haven't really applied probabilistic analysis to some of these issues. It's been something one of my first bosses, who actually invented and licensed, called rough justice.

[00:34:10.14] [LAUGHING]

[00:34:12.39] So which was, I can tell you how many times you look at these analysis and well, we think we should be protected to one meter separation. And the commission would go, no, we think it should be two meters or three meters. There was no like, well how often do people get one meter apart where the power is exceptionally high, the signal is exceptionally weak.

[00:34:33.93] and I think one of the things that has happened to-- and I think this was touched upon in David's group, was we've gone from most of these things, at least in my view, have been around the edges. Not always, because sometimes when you're dealing with a satellite service, you increase the noise flow. They can lose a whole area. So so I get that.

[00:34:56.72] But the arguments get translated for PR purposes and for other decision makers who understandably don't know all of the minor details of what's going on into we're going to lose this service. When in fact, it's well, an inference that just because your primary does not really say zero interference, although that's how that's applied. And people understand it that way.

[00:35:27.28] But in actuality, there's always going to be some interference out there. And when we talk about it in terms of what is harmful, I think a reasonable way of looking at it is, look, it's the exceptional case. What do I mean by that? We used to define your service area with a contour.

[00:35:52.15] We used to say, here's where you can kind of expect your service to be. And here's the level. We'll apply it.

[00:36:00.22] If you can get service out there, great. That's wonderful. Nobody's telling you you can't. But we're not going to protect you down to minus 150dB.

[00:36:10.45] And I think we've lost some of that through the years, as to well as defining defenses. In some cases, they're just gone. And the incumbent says, "Well, here's-- I've got some stuff that can operate this low.

[00:36:25.87] And I've got customers who've been able to get service that way." And yet it's an opportunity cost to whether you can introduce some new service. So just to go full circle. It's taking these recommendations how you translate it into something that's truly actionable.

[00:36:49.09] ANNA GOMEZ: So is there a recommendation that you would make to Silicon Valley as to what they should do next?

[00:36:54.79] PAUL KOLODZY: I think, and I think this is generally across the board for both cases. On the process side, I think, and I think

things are going in the right direction, personally. It's like, terrific that under the MoUs there would be the meetings.

[00:37:14.35] What's really important is what happens in those. Do they become the vehicles to resolve conflicts or-- and I'm not suggesting this is what it would be. Or is it, we'll just tell you, we'll tell you what we think, you tell us what I think and we'll walk away and say, and I'm right and you're wrong.

[00:37:32.45] There has to be a process here to where those levels, whether it's, look, we want, we've listened to the staff from both sides. We're not as convinced. We think you need more work here, there. Come back to us. Try to figure out if there's some way you can live together and make this work.

[00:37:52.70] So I think a little bit more depth, really, in terms of the recommendations on how you solve this. And I think for the second group, there was a lot of stuff thrown up there. Seems to me, I'd look down the road at what the conflicts, I can tell you what they're going to be. It's pretty obvious we're going to be wrestling with the passive services, which are in a lot of places. And trying to understand how we can make those things work.

[00:38:25.33] I think we're struggling-- sorry to go on so long. But for years and years, it was like here's the source, here's the victim receiver. And we're going to have one path and so forth. And here's the power level and it's much more complicated now.

[00:38:40.96] It is like I've got to adapt to the antennas that it might be pointing here one second and the next. The power level is varying. And then how you add up for out-of-band emissions, which is like has become such a key argument here.

[00:38:59.26] Multiple base stations and reasonable deployment scenarios and so forth, and figure out what those levels are. Because I don't know that we've done enough work to look at the models and see do they really match reality? And you're going to have more and more of those arguments. These arguments that we've been having about adjacent channel interference, which used to be just the two next door are now several megahertz away. And when you start to look at root causes, it's usually about how the analyzes are done and how that sets people off about what's going to happen.

[00:39:38.27] ANNA GOMEZ: Jonathan, did you have something? I'm sorry.

[00:39:41.31] JONATHAN WILLIAMS: That was so wonderful.

[00:39:42.11] [LAUGHING]

[00:39:44.67] ANNA GOMEZ: You think?

[00:39:45.57] JONATHAN WILLIAMS: No, I think, yeah, I think Julius is very spot on as far as expectations are concerned. That word risk there is pretty-- that's doing a lot of work. It's kind of a heuristic.

[00:39:59.73] I mean, when you think about it, the risk analysis is going to be very different for a satellite provider is trying to meet their service agreements or service standards versus a radio receiver that's designed just solely around or primarily around sensitivity and is potentially damaged by a signal that's too strong. The risk analysis has to be different, especially if you're talking about a many, many or million dollar instrument.

[00:40:34.59] So the expectations are going to be different. I absolutely agree. And I think I really do agree with that point for in the context of it's going to be a case by case thing.

[00:40:49.95] ANNA GOMEZ: Thank you. I think, yeah, we're about 15 minutes out so maybe we should open it up for the student's question? Anybody? I will call on somebody who looks young.

[00:41:03.94] [LAUGHING]

[00:41:06.82] SPEAKER: Julie.

[00:41:07.84] [LAUGHING]

[00:41:09.34] AUDIENCE: So in keeping with the theme of the necessity of more people moving into this area, I think on behalf of myself and the other students here, what are some areas that you see being in most need of new people entering the field? Where can we go, how can we help?

[00:41:31.14] ANNA GOMEZ: Good question.

[00:41:34.27] DAVID GOLDMAN: Satellite.

[00:41:35.54] [LAUGHING]

[00:41:38.78] Yeah, yeah. Give me a call. It's totally true. We've got like a whole new generation of satellite stuff that's coming. I think the rule, I don't think there's anyone who's defending the current regime of rules and saying that this is going to be robust enough for this new generation.

[00:41:56.17] I think it's only growing. So in all honesty, I actually think that there's a lot of interesting work that's going to be going on there. And I think it would be having an infusion of fresh perspectives. It would be really, really useful.

[00:42:10.65] JULIUS KNAPP: So lawyers play an important role in all this. It's not a slam at lawyers. But I also wish that we were doing this in an engineering school.

[00:42:23.87] [LAUGHING]

[00:42:28.57] [APPLAUSE]

[00:42:34.94] So the lawyers take the arguments, try to understand them and present them in a way to convince people of the merits of their argument. The engineers, when we start having this like propagation in what signal strength you're going to receive, there is such a dearth of people who understand this and come.

[00:43:02.53] We've got to figure out, I think, a way and a spectrum is kind of focused on this. And I know I talked to Tom a little bit ago about how do we-- I think one of the things we miss is tying the wonderful things that come out of this work. Is we have these arcane discussions about spectrum and back and forth.

[00:43:23.61] But not tying it into-- This enables everything that you're doing, whether it's with your phones, whether it's social media, whether it's safety of aircraft or safety of transportation. And those, if you would sit down with folks and say, here's how this fits and how you can have an exciting job in making these things happen.

[00:43:53.06] Because we-- and honestly, Paul and I, we were joking before you looked around the room, and what you'd ideally like to see out there is a diverse community. Different backgrounds, men and women. And that's coming up the ranks than when you walk away from it. You know It's in good hands behind.

[00:44:17.16] And I think that's the real challenge right now is trying to take, whether it's students or how we come up from a military background or training programs and other agencies, people who can understand these arguments and sort from the risk, where it's like no, that's pretty rare that that is going to happen to no, this is a real problem. We've got to find a way to fix it.

[00:44:48.23] ANNA GOMEZ: You actually remind me how important it is to have-- Let me say this a little bit different. The most successful engineers I know know how to talk to non-engineers and explain to them the issue without losing them. Paul.

[00:45:03.20] PAUL KOLODZY: Yeah. I want to first start with what you just said there. For the engineers that are in the room that are young, is to learn how to communicate in not-engineering terms to folks. I mean, that was one of the things that Julie and I have had lots of discussions. And the ability to actually talk to the engineers.

[00:45:19.10] Peter used to come down when I was at the FCC and we would talk there. And I would-- my job was to make sure it's they understand what I was trying to get at, and he could put it in the right context. For the young people who are in the legal profession, I think what you need to do is understand there's a breadth of things going on in multi-networking, which includes satellites and the like.

[00:45:42.02] And that's going to change things. It's going to change things. It's going to be multiple-- It's not going to be one party against another party. It's going to be multi parties going together and what are the optionality associated with that? I think you have to embrace technology versus saying technology doesn't matter.

[00:45:57.08] I think most of the smartest lawyers that I've seen and the most successful ones have actually said, let's go to lunch. Could you just explain to me how does this actually work? And then try to put those in terms. I remember talking to the chairman, it was Michael Powell at the time. And he basically, we're talking about UWB.

[00:46:14.33] And then through conversations, he was sitting there going, ultra wideband. Ultra wideband communications, so you got an engineer. And that was a big thing back around 2000, 2001, 2002. And I basically tried to explain to him in very simple terms with gnats. And one gnat flying around the backyard is not a big deal. But a billion gnats flying around the backyard could be a big deal and he goes, "Oh, this is nuisance law."

[00:46:39.60] And he was trying to actually tie it to different areas. And it was intriguing to watch the minds and trying to actually get those interesting things to work together. So I think that in the legal community, there's a lot of interesting problems going on here in the sense that it's no longer one on one. It's going to be also this, all this cross between talk and how you actually understand some of the stuff.

[00:47:00.65] For the engineers in the group, the risk assessment we're talking here and starting to embrace the complexity versus running away from it is that that tends to be the problem that I see with most engineers. Like I can't understand this. I'm just going to go and see what happens versus saying step back. Ask the root questions. What's going on?

[00:47:22.31] These are the things that we used to argue about. Julie and I would have lots of arguments in the FCC, talking about what are the root causes and how we can actually start to make aggregation arguments and [INAUDIBLE] That's really interesting and rich area of research. And actually, will actually spawn many of the new things that you're going to see when you're going to get terahertz, which is going to be very short range.

[00:47:40.78] Optical communications going on there. Multi-networking going on. Multiple, when they start actually splitting up and having multiple services actually crossing the boundaries and actually intermixing. All of this stuff is occurring right now and it's going to be really happening in the next 20 years.

[00:47:55.13] So in some sense, this is not incrementalism anymore. This is going to be actually earth-shattering changes in the way satellites are going to make big impacts and how we actually do

communications, and how that flows into the terrestrial networks. I think it's an exciting time. I think you should just embrace-- as they say, embrace the complexity.

[00:48:12.67] ANNA GOMEZ: Want to go, David?

[00:48:13.87] DAVID GOLDMAN: Oh, go ahead.

[00:48:14.89] ANNA GOMEZ: Jonathan?

[00:48:15.43] JONATHAN WILLIAMS: Well, I was just going to say I come at this from a spectrum management standpoint, particularly international spectrum management. But I know of no entity involved in spectrum management that I would consider adequately staffed when it comes to spectrum management. I mentioned before, they steal people from each other, it is true.

[00:48:33.40] And I think objectively, that is true. And it's not just the federal agencies. I have a colleague, colleagues in places like CTIA, who laugh at 40 hour workweeks. This is an ongoing challenge and it is something where no matter what background you come from, you're going to be learning something. They don't give PhDs in spectrum management, at least not yet. So if you come from a legal background or engineering background, yeah, you're going to need to learn to talk to people.

[00:49:01.72] You're going to need to learn the venues. You're going to need to learn everything that the other people know. So I don't know if that directly answers your question, but no matter whether you go into the spectrum management side or if you're more interested in the innovation side. There is a need and you're going to be learning a lot.

[00:49:20.89] ANNA GOMEZ: I've always wondered whether we needed to have an exception to the government pay for engineers.

[00:49:26.01] [LAUGHING]

[00:49:27.12] JONATHAN WILLIAMS: You're asking me.

[00:49:29.24] ANNA GOMEZ: But I mean, in all seriousness, the companies steal from government. The law firms steal from government. And it's hard to turn down the bump in pay that you get when you leave.

[00:49:40.21] JULIUS KNAPP: So actually there was a time when that happened.

[00:49:44.43] ANNA GOMEZ: Oh, when it was sales?

[00:49:46.17] JULIUS KNAPP: It was--

[00:49:48.00] ANNA GOMEZ: Was senior level.

[00:49:49.38] JULIUS KNAPP: Well, it was not just senior level and it was all the way back when I started. It was-- There was a separate pay scale for engineers, up to, I think a GS-12 level or something like that. And the selling point for government was in all candor, was you'll start here and it's less than the offers you have on the table now. But when you get up to here, you'll be higher.

[00:50:17.08] And there was an attractiveness to that. In whether anything like that can happen, I think, is an open question. But it did happen before, at least in a particular context.

[00:50:33.57] ANNA GOMEZ: Should I give, yeah. There's a question in the speaker section.

[00:50:38.91] [LAUGHING]

[00:50:40.31] AUDIENCE: More of a comment thatn a question. As someone who has given up that paycheck for a number of years working for the government, I don't think it's the salary that's a problem. I think the idea that we're sitting here in this quagmire of not making decisions. It's not exciting work.

[00:50:56.97] We're not giving engineers a reason to be excited about going to work so that they can hear policy people tell them no. They go out into the commercial world because they can make a difference. That's where I think some of the brain drain is coming from. It's not just the salary.

[00:51:14.39] ANNA GOMEZ: Thank you. Dale? You need to wait.

[00:51:19.19] DALE: Oh, I'm sorry.

[00:51:20.28] [LAUGHING]

[00:51:25.61] AUDIENCE: This is slightly off topic, but we're here in the law school and this seems to be a very propitious time when we're talking about structure and process regarding interference. And so spectrum management, and I've not heard yet the Chevron deference which could dramatically change the relationships between--

[00:51:52.14] I'm not a lawyer, see, but it seems to change, it makes a major change between Congress and the regulated age. So perhaps somebody should define Chevron deference. But I'd be interested in your reaction to how serious a threat that is that things we're talking about.

[00:52:14.29] ANNA GOMEZ: That's a really interesting question, especially since we just had this whole discussion about how much Congress should be involved in spectrum management and dictating outcomes.

[00:52:23.55] [LAUGHING] David. So maybe we can get a law student to tell us what Chevron deference is.

[00:52:32.84] [LAUGHING]

[00:52:36.70] DALE: All right, mic's already in my hand. Just a two-step process that courts go through to check whether or not Congress has allocated a certain authority to a agency. The first check is whether or not the statute was ambiguous on, if the federal agency, the FCC or whatever has the power to do whatever it is they are trying to do. If it is found to be ambiguous, then the court is going to defer to the agency's judgment as long as it is-- somebody help me with the term that the court uses.

[00:53:12.67] AUDIENCE: Not arbitrary or capricious.

[00:53:16.67] [APPLAUSE]

[00:53:19.60] ANNA GOMEZ: That was very impressive. But Dale, you're raising a very serious issue. If suddenly we lose Chevron deference, then suddenly, arbitrating disputes is going to become a little more complicated.

[00:53:33.50] JULIUS KNAPP: Maybe I'll just say a word on the technical side because I don't know what things would look like if it went away. But I do know how it works now. And they're generally not substituting a judgment for things like, well, you said it's 3dB and I think it should be 6dB.

[00:53:54.67] But if the agency has not explained how it reasoned to get to its answer, generally what happens is it gets remanded and then the agency needs to either go through a process to better explain how it came to its conclusion. Sometimes there's an additional step. I mean, there was a gap and once you did-- and the agency decides to resolve this, we're going to have to go to another step.

[00:54:26.74] But it's, at least now, I can't think of a case where the court came back and said, no, we're going to substitute our technical judgment for your judgment. Uh-oh, they'll thought of something.

[00:54:43.15] [LAUGHING]

[00:54:44.35] DAVID GOLDMAN: No. I was just responding, because there, the way you ask the question is does it change the relationship between Congress and the agencies. And I'm not sure that relationship changes so much. Congress gets to where it gets to for its own issues.

[00:54:58.60] I think the relationship between the agencies and the courts will change. I think things get remanded a lot more. Maybe not a lot more, but I mean, I've definitely seen cases, I mean not just FCC, but just across everything, where courts say, I'm not sure I agree with where the agency is, but we give them deference because they're the expert agency.

[00:55:19.06] And so then they just let the decision stand. And if we lose Chevron deference, I think that may not happen as much. I think

we may start getting more of the demands of like you really shouldn't have come to this decision. Go back and try again.

[00:55:29.35] I think you're probably right. The judges, for the most part, don't want to try to become RF engineers in our world. But it's I think they might be much more willing to go start sending stuff back to the agencies.

[00:55:40.15] ANNA GOMEZ: I think David had his hand up.

[00:55:41.69] DAVID: I can't believe I'll be the defender of the FCC, but I would say, I will say it seems from having spent a lot of time doing this anyway, it's pretty clear that the Communications Act gives the FCC the authority to define harmful interference. I don't think that's a Chevron question, I think that's a textual question.

[00:55:59.56] ANNA GOMEZ: OK. I know we have time for one more question because he's been very patient.

[00:56:05.85] AUDIENCE: Yes. Great discussion here. And I would like to open up. I don't want to say a whole new discussion.

[00:56:15.12] But to the lawyers in the room, the young lawyers, I hope they're taking water law here at University of Colorado Law School. One of the few that I understand teach that. Why is that important to this discussion? Julie, Dale. These guys have labored for decades in trying to move from an exclusive use model to a shared use.

[00:56:41.22] And with shared use, it implies at least that you have peers with equal rights. Water law and spectrum law under the first come, first serve type of paradigm or doctrine tend to have a superior right. And so the engineers, the lawyers, I think need to work together with the economist in trying to move toward a more peer-to-peer balanced approach versus the water law approach. Any comments on that?

[00:57:18.01] JULIUS KNAPP: Not so much on the water law but just one little tip for the attorneys. At least in my view, the best attorneys and advocates are the ones who take the arguments from the other side seriously and try to work things through to get to an answer. The comment process is not the greatest way to resolve things.

[00:57:45.92] You throw somebody something in and somebody throws in their response. I mean, time and time again, the attorneys who worked with their clients to try to come to some sort of meeting of the minds with the concerns that have been raised have been the most successful.

[00:58:06.35] ANNA GOMEZ: Any thoughts on the water law question?

[00:58:07.85] DAVID GOLDMAN: I just, it's funny you say that. When I talk to students all the time, I recommend research into water law specifically. Not necessarily-- We've been doing spectrum stuff for a

number of decades, but we've been doing water issues for centuries, millennia.

[00:58:27.06] And I just, I keep saying-- I actually think that we need to, in general, be looking for other sources of where there may be similar problems and we may have solved it in different ways to see if we can inspire some of our thinking. That I don't know that we're reinventing the wheel over and over again here in spectrum. I think that there's places-- you mentioned nuisance law.

[00:58:46.89] I think there's places where some of these issues have been addressed before. And I actually think students are really well placed. One of the things that also students ask all the time is like what kind of classes should I take? And my advice is usually, go take classes and a whole bunch of stuff that doesn't seem relevant to where you want to be. It's the last chance that you get to do that.

[00:59:03.73] And the biggest insights, the biggest jumps we get in thinking is when someone says, oh, actually this issue that you think is intractable was solved somewhere else. And if we import that idea here, we can actually take another leap in how we think about it.

[00:59:18.64] So I'm not sure water law specifically. I don't know enough about water law, frankly, to know whether there's specifically, in water law, that's the lessons we need to take and that'll solve spectrum problems. But I do think that idea of looking in other places. And I think this is going back to the students and asking about what you want to do.

[00:59:35.07] I really think, take advantage of all the classes that you can take here. And also University of Colorado is great, that you have great engineering schools. You've got great other schools. Go see if you can take classes outside the law school because I think you'll find that there's some interesting insights that you'll come back to the legal stuff that you want to do and have new ideas that nobody had thought about before. And I that's really where we can get some innovation.

[00:59:56.73] ANNA GOMEZ: All right. I think we do need to stop here. Thank you very, very much to all the panelists. They really got no notice about what they were going to discuss, so

[01:00:06.79] [APPLAUSE]