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Transcript

Inaugural Space and Spectrum Policy Conference

Challenges in Sustaining Space as a Resource

June 24–25, 2025

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Day 1: June 24, 2025

Keynote: FCC Commissioner, Anna Gomez

https://youtu.be/9gGa62wtUFY?si=XlvpHPTyp8On5o2C

[00:00:00.17] BRAD BERNTHAL: All right. So 2 and 1/2 years ago, JP DeVries, and I saw JP somewhere. There he is. JP sat me down for a coffee, and he said, Brad, space activity, this is ramping up in a hurry. And just as important, law and regulation is having a very difficult time keeping up.

[00:00:21.77] And he said, this is an area where Silicon Flatirons could really make a contribution, first of all, important issues related to spectrum that are going to be in this domain. And second, there's just hard problems on the horizon, where it's going to take a lot of different kinds of skill sets in order to find better answers when it comes to law and policy.

[00:00:45.38] I said I'll look into it, which usually in academia means we won't do anything. But we actually did look into it. In fall of 2023, we hired a fellow, Matt Gaske, who did a deep dive for us. And we not only saw that JP was right about those things, but it became clear that Colorado, and more specifically CU Boulder, is a really terrific place to be conducting some of this work.

[00:01:11.21] In terms of private sector activity, as many of you in this room already know, there is a layer of startups, a layer of emerging companies, and a layer of primes all active here in the front range. And the CU campus is a powerhouse in terms of space activity. We have a highly ranked aerospace department. We have the renowned Laboratory for Atmospheric and Space Physics. Dan is going to be part of this. He recently stepped down there. And Dan just most recently stood up a center here on campus, Space Policy Center. I encourage you to follow up with Dan on that.

[00:01:51.26] And then last summer, we went further. The leaders of our spectrum initiative, Dale Hatfield and Keith Gremban, organized a roundtable discussion with help from others, including Peter Tenhula, and we produced our first space roundtable report last fall, which brings us to today and tomorrow's set of public discussions.

[00:02:13.78] Phil Weiser, who many of you know, founder of Silicon Flatirons, always said there's two ways to win at a conference. Butts in seats and good conversations. I think we're going to nail both of those. Although with the butts and seats, I was a little worried about that. Summer in June, and I was like, oh, summer in June, come to Boulder. Maybe an easier sell than February. We'll see how it pans out.

[00:02:34.33] But on content, we've really got a terrific lineup of experts tackling timely, pressing questions. And this is such an

interesting moment in space and space policy, tremendous opportunities and exciting things going on as the costs to be involved in space activity dropped dramatically.

[00:02:55.48] And even though space seems large, as this activity proliferates, we're realizing that there are resource conflicts about how to use it, and this conference examines the questions about how to use space resources well and how best to regulate it. Lurking behind this are important institutional questions, including which regulatory bodies, domestic and international, are equipped to develop, implement, and superintend intelligent space policy in the years ahead. Special thanks to Dale Hatfield.

[00:03:40.09] Spoiler. That's not going to be Dale's last round of applause for this conference. And Keith, Gramben. Keith. Putting this conference together. And game balls also go out to Peter Tenhula, David Reed, David Redl, and Stephen Shimbin. Now round of applause for them as well, who helped put this together.

[00:04:04.96] All right. Here's how we're going to proceed this morning. After a moment, a student here at Colorado Law, Sarah Joy Caster, will introduce Commissioner Gomez for her keynote address. Students, as those of you who have been here before know, are closely involved in just about everything we do at Silicon Flatirons.

[00:04:24.40] Even during the summer, the wiser rule applies. So for the students who are here on campus, we'll be looking to you for our first question. And I strongly encourage you to take time to visit with students upon advice on them while you're in Boulder.

[00:04:39.56] Then we'll have, after Commissioner Gomez's keynote, we'll have a panel which examines spectrum conflicts between active users in space and on Earth. Then a 15-minute break. Following our break, our last panel of the morning analyzes orbital space as a resource. And then I encourage you to stay. We've got a very special presentation before lunch. And that's where we are going.

[00:05:10.29] In terms of the law school activity, I was remiss in failing to mention that our engagement in space law and policy, in addition to what I highlighted with JPS involvement, students have been leading the way now for three years, and our Student Space Law Society has been a real engine for this. Delighted to have Sarah Joy here to introduce today's first speaker. Sarah Joy.

[00:05:38.34] SARAH JOY CASTER: Good morning, everyone. I am Sarah Joy Caster, a second year law student here at the University of Colorado and the vice president of the Space Law Society. Thank you all so much for joining us today online and in person. It is my great privilege to introduce our first keynote speaker, FCC Commissioner Anna Gomez.

[00:06:01.03] With more than three decades of leadership in domestic and international communications policy, Commissioner Gomez has guided spectrum strategy from nearly every vantage point, from federal agencies, Capitol Hill, the private sector, and the international stage.

[00:06:17.31] Throughout each role, Commissioner Gomez has advanced the ambition to turn scarce spectrum into endless opportunity. Commissioner Gomez work continues to ensure that the airwaves remain a catalyst for innovation, resilience, and universal connectivity. The themes at the heart of this conference. So please join me in giving a warm welcome to Commissioner Anna Gomez.

[00:06:46.68] ANNA GOMEZ: Good morning. Wow. Everyone's had their coffee. So congratulations, Silicon Flatirons, on your inaugural Space and Spectrum Policy Conference. As per usual, Silicon Flatirons is at the forefront of policy conversations. So thank you for the invitation to speak with you today. It's great to be amongst industry leaders, and I look forward to learning from all of you as we launch into important conversations about the role of regulation and international cooperation in the new space age.

[00:07:22.89] It's also great to be here at the law school. Everyone knows I heart Silicon Flatirons. I do have a CU law intern this summer. I've had several. It might have something to do with the fact that Edyael Casaperalta is my legal advisor but also a former or a CU alum I should say. So she might be a little biased as well.

[00:07:48.00] So space has been at the frontier of technological and communications innovation for quite some time. It used to be that only the most adventurous would dare to seek their place amongst the literal stars. There is a reason why culturally, our point of reference, for something being easy, is to compare it to something incredibly difficult to do, rocket science.

[00:08:11.73] But we have come a long way since Telstar. For example, an industry report estimates that since 1957, entities from 102 countries have deployed at least one satellite. And that today, US entities operate over 8,000 satellites. Indeed, in recent years, barriers to enter the world of space exploration have lowered, creating opportunities to innovate.

[00:08:38.30] Over 11,000 small satellites have been deployed between 2022 and 2024. And today, there are 618 GO and over 10,000 NGSO active satellites. The global satellite industry revenue for 2024 is estimated to have been a striking $293 billion. In other words, it's a great time to host a conversation about space policy.

[00:09:05.66] The FCC's role in space policy is to authorize commercial systems, facilitate efficient spectrum use, ensure responsible orbital debris practices, and coordinate with international fora. In practical terms, this means that the FCC licenses space stations and earth

stations, ensures that operators have orbital debris mitigation plans, and engages in payload review processes with corresponding federal sister agencies, and issues experimental operating authority licenses that facilitate continued space innovations.

[00:09:40.82] Our regulatory authority focuses on the activities of space companies that operate domestically within our geographical boundaries. But authorization in the space sector also takes us beyond our boundaries. Space, by its very nature, is inherently international, and thus policy for space communications is inextricably tied to successful cooperation with international bodies and other nations.

[00:10:08.30] In that regard, the FCC is a critical player in engaging with international bodies to further US leadership and in helping domestic operators fulfill the international satellite coordination process pursuant to ITU requirements governing the use of radio frequency spectrum. To put it succinctly, our role in space communications and innovations, both domestic and global.

[00:10:31.49] As a commissioner, I am focused on supporting American innovation and leadership, and I deeply understand the importance of strong relationships and good faith cooperation to maintaining our success globally. I recently went on a brief space tour to learn more about companies leading the new space age from right here in the United States.

[00:10:54.04] I had the opportunity to visit established and emerging companies in Los Angeles and San Francisco and institutions that are part of the growing space economy. My goal with these visits was simply to learn. Learn about how these innovators are contributing to the field, as well as to discuss ways in which the FCC can better promote competition in the space economy.

[00:11:17.17] I visited satellite manufacturers and operators like Astranis, Rocket Lab, K2 Space, and Planet, a mix of established and new entrants that are manufacturing satellites, each within their own unique signature in California. These companies are making their own mark in a segment of the space economy, and they exemplify the new era of commercial space.

[00:11:41.18] For example, Planet's approach is to image the entire Earth every day with their own satellites and to make that imaging available to a variety of clients. This type of imaging has previously been accessible only to some governments. In a world revolutionized by small satellites and more accessible launches that can carry bigger payloads farther into space, K2 Space is bringing it back to basics and differentiating themselves with large, powerful satellites for high throughput.

[00:12:14.77] And with an ever increasing demand to put more communications infrastructure in space, we all understand the need for more access to launch capacity. So I was glad to have the opportunity

to visit Rocket Lab facilities and see firsthand their innovative rockets. I also had the chance to visit Apple and to learn about its groundbreaking partnership with Globalstar to provide emergency satellite connectivity.

[00:12:41.32] And no space tour is complete without nerding out with the most famous nerds on the planet, NASA. I was able to visit NASA's Ames Research Center to learn about their exciting new missions. For example, I learned about missions involving solar sails and spacecraft swarms conducted by the Small Spacecraft Technology Program, which tests the capabilities of small spacecraft for exploration, science, and the commercial space sector.

[00:13:12.61] Solar sails use the pressure of sunlight for propulsion the way a sailboat is powered by wind in a sail, thus eliminating the need for rocket propellant. And swarms test the ability of small spacecraft technology to fly cooperatively in a small group to enable multi-point science data collection.

[00:13:35.32] Visiting these companies and learning about ongoing federal research made me even more excited for American innovation and global leadership in space. And meeting these space innovators highlighted the critical importance of competition and spectrum management and in the space sector overall.

[00:13:52.89] Space is an exciting frontier of discovery and innovation. Explosive growth in this sector domestically and internationally has meant new opportunities for entrepreneurs and visionaries. But it also raises new questions for regulators like the FCC, particularly around striking the right approach to responsible space use that supports competition and innovation.

[00:14:16.92] As our country increasingly relies on space-based connectivity to eliminate mobile dead zones, provide greater national security capabilities, and lead space communications globally, we must ensure that a robust and competitive ecosystem exists that expands consumer choice, lowers costs, and drives further innovation. Sustaining space competition and leadership requires multiple healthy competitors. Our policy decisions cannot lose sight of that.

[00:14:47.07] In the last few months, I voted on items that explore the possibility of making more spectrum available for space communications. These items include questions about the benefits that could come from opening up new bands for space communications use, but I also ask the public to comment on potential challenges. Some of the bands under consideration in these items were already under study, while others were considered pursuant to requests made by industry.

[00:15:14.64] Asking questions early in spectrum management is critical. By identifying potential incompatibilities and hurdles early on,

we walk a data-driven path towards consensus for sharing this finite resource amongst competitors.

[00:15:31.20] On the other hand, failure to ask questions has caused problems in the past. Failure to coordinate obstructs our ability to identify potential problems and incompatibilities, which can eventually cost the industry time and money. And failure to address critical differences can lead to future challenges and collaboration, subsequently making it more difficult to reach consensus and effective long term spectrum policy.

[00:15:57.36] The very nature of space technology and spectrum use in space demands that we explore the tricky questions and cooperate in good faith. Satellite footprints are often large and may cover more than one country, making frequency coordination especially important to avoid interference with other satellites and terrestrial networks.

[00:16:17.92] That is why cooperation is critical for sustainable space policy. We don't occupy or control space alone. In the space sector, domestic decisions provide a global example. Practices that demonstrate interagency cooperation breed cooperation globally. Policies that support competition domestically inspire competition globally.

[00:16:42.81] From ensuring respect for orbital slots to decisions on how to fairly manage access to high frequency satellite bands, so that all countries and satellite operations can benefit, we demonstrate that cooperation and respect for competition starts at home. In short, our domestic policy decisions about space are inextricably connected to international conversations.

[00:17:05.88] One only has to take a look at the agenda for the upcoming World Radiocommunication Conference in 2027 to appreciate the new space era we find ourselves in and the importance of astute diplomacy. The majority of the 31 agenda items slated for discussion at the WRC '27 will involve space and satellites.

[00:17:27.01] In broad strokes, the agenda indicates conversations will surround expanding spectrum access for satellite use, ensuring equitable access to satellite spectrum, protecting research and scientific services, and improving international procedures for allocating spectrum in a rational, efficient, and economical way.

[00:17:47.88] Space policy connects communications infrastructure beyond a nation's borders. Harnessing the strength of soft power and diplomacy are therefore key to achieving success. This is where early cooperation practices domestically have the potential to fuel cooperations internationally.

[00:18:07.80] A well-coordinated approach domestically lays the groundwork for successful cooperation internationally. Showing up together makes an impact, and our unified presence on global stages

like the WRC is critical. Fortunately, we can utilize international bodies and institutions to encourage harmonious cooperation for the benefit of all.

[00:18:32.75] International institutes like the International Telecommunication Communication Union and the Committee on the Peaceful Uses of Outer Space are critical to facilitate collaboration, particularly in moments of disagreement. Setting global policy for the use of space spectrum is an art.

[00:18:51.30] As policymakers, we champion US leadership without losing sight of the independent nature of fruitful international cooperation to our success. Our role is to continue to build relationships with regulators around the world, to advance positions that support US leadership and ingenuity.

[00:19:12.00] I look forward to the opportunity to bring my expertise in domestic and international spectrum policy to our collective efforts to support continued use of the space spectrum that centers on competition and innovation. Thank you.

[00:19:36.20] All right. So here, I can take questions. And Weiser rule.

[00:19:41.25] BRAD BERNTHAL: The Weiser rule is in effect. So first question goes to a student, and then we'll take audience questions. Do we have a student question? Let's go over here. And I think we've got a microphone coming down. Thanks.

[00:20:01.82] AUDIENCE: Hi. I was wondering how our upcoming mid-band spectrum oxygen's going to impact like smaller satellite startups, and are they going to have access to those?

[00:20:17.21] ANNA GOMEZ: So we have one spectrum auction coming up because we are authorized to have one spectrum auction right now. How they impact small satellites is a good question. So satellite providers don't get their spectrum via auctions. And part of the reason for that is the inherently international nature of satellites.

[00:20:43.58] So I would expect that small satellite providers would actually not participate in the auction, and I would have to see what the rules of the particular bands are for whether they would be able to even operate in those bands on a shared basis with terrestrial providers.

[00:21:03.05] So we only have one auction coming up. Congress is working on getting us some more authority right now, and I really hope that they get us that authority, so that we can start conducting auctions, that there's a lot of pent up demand for that. But not sure it really affects the small sats.

[00:21:23.18] BRAD BERNTHAL: Let's open up for questions. Let's come over here.

[00:21:34.93] AUDIENCE: Commissioner Gomez, thank you for being here today. A pleasure to see you again. Just want to throw a softball question at you about the Space Bureau and the interactions the bureau has with state, Department of State, and what that looks like for the benefit of the audience.

[00:21:53.38] ANNA GOMEZ: Thank you for that question. I talked for like half a sentence about working on an interagency basis. But it's a really good question. We, the FCC, our mandate, which is the authorization and allocation of resources for telecom and for space.

[00:22:19.48] But we have sister agencies throughout the federal government that also have equities in this area. You mentioned State Department. The State Department, of course, leads US interactions with international bodies. They are the leaders of our efforts at the International Telecommunication Union. And so it's very important that we interact with them.

[00:22:50.27] They also work with us when we have complaints from other countries about our activities in space by our authorized providers. We work with NTIA as we prepare for the world Radiocommunication Conference coming up, which is the international body that makes decisions on international allocations of spectrum.

[00:23:14.59] And through the NTIA's efforts, the National Telecommunications and Information Administration efforts, we also cooperate with agencies that have equities in whatever the technology is that we are authorizing or the spectrum that we're authorizing for commercial uses, whether they be the most famous nerds on Earth, NASA, or DOD, or pretty much any agency that has anything to do with spectrum. So it's very important that we have collaboration and cooperation, and the Space Bureau is an important part of that.

[00:23:50.83] BRAD BERNTHAL: Let's go back here.

[00:23:59.73] AUDIENCE: Thank you, Commissioner Gomez. So appreciate your comments. I'll put my cards on the table and say that I'm an astrophysicist. So as you know, I'm sure, that we have been continuously losing access to the frequencies that we get from the universe, which is our way of understanding the universe.

[00:24:19.99] Of course, we put in comments to the FCC, and we do all of the things. But when we talk about auctions, I have to confess that my blood does start to boil just a little bit because as astronomers, you know, without deep pockets, we will never have the ability to participate in auctions, at least not successfully, I think.

[00:24:40.57] And so we do have, as you know and I think many people in the room know, some very small slivers of spectrum that have historically been allocated to radio astronomy, but even those are now under threat. So I'm just wondering if you have comments on that landscape. And I also just want to put on that-- let folks know there are

some astronomers in the room who have different perspectives on some of these issues.

[00:25:04.86] ANNA GOMEZ: We always say that astronomers are sensitive, and they're sensitive from a spectrum perspective. But yes. This is a perennial issue. I mean, I've been doing spectrum now for a long time, decades. And it's difficult because deep space work, scientific work, whether it's weather, whether it's astronomy, is sensitive, and it needs protection from uses that may interfere. And it's difficult, and it's a difficult balancing act, I have to admit. And that's why this interagency cooperation and collaboration is so important.

[00:25:52.89] One of the things-- I'm not saying this is going to solve the issue, before someone asks me about it. But when we were at Nasa, one of the things that they were telling us is they are now looking to use lasers instead of spectrum. Not for everything. This is one project they're working on, which I thought was very interesting. It's sort of a recognition, all right, we got to figure out how to make this work because spectrum is getting more and more congested, and it's getting more and more difficult to balance all of these interests.

[00:26:23.44] So I'm not answering your particular issue. I don't know what the spectrum band specifically you're talking about. But I do recognize that this is something that is more and more coming up as we look particularly at using the higher frequencies.

[00:26:38.84] BRAD BERNTHAL: Let's go to the back.

[00:26:44.60] AUDIENCE: You're talking about how much we need more interagency cooperation, and you mentioned NASA many times, and their workforce is supposed to get cut from 17,000 to 11,000, as will other government agencies. So how can we count on this interagency cooperation happening anytime soon?

[00:27:04.52] BRAD BERNTHAL: Maybe I'll augment that question as well. So that's one trend line that's interesting to think about. But also the fact that you're out in the field, gaining more expertise in this emerging area. Do you have additional thoughts about institutional competence at the FCC in terms of building muscle around this?

[00:27:22.35] ANNA GOMEZ: Yeah. That's an excellent question. I have been alarmed by this administration's efforts to cut federal workforces, to cut science in particular. I am concerned about what's happening even at the FCC, where we have seen a lot of our institutional memory leave due to what I call the terrorism from this administration that's causing people to leave early, to take early retirement, and to take the fork in the road. I worry a lot about our engineering expertise in particular because those are the most difficult to hire and the easiest to poach by industry to be honest.

[00:28:08.27] So you raise a very good question. The more you cut expert staff, the more difficult it's going to have these conversations.

And the more the agencies are going to focus on their own missions, because that is the natural thing to do when you have a mission and you have fewer staff, then you are going to really focus just on that staff and not on cooperation with other agencies who have other missions, even if they affect you. So this is a very significant issue that you're raising and a concern that I actually agree with.

[00:28:41.96] BRAD BERNTHAL: Let's come to the front. We got a microphone on.

[00:28:56.60] AUDIENCE: Thanks for being here. I wanted to talk to you more about the FCC's regulations on orbit altitude. We have several spacecraft flying right now that are getting down into the SpaceX's Starlink satellites and started getting emails 12, 24 times a day about collision alerts and all that kind of stuff that we had to do.

[00:29:23.10] So we actually raised our orbits a little bit to stay out of there. And then the Kuiper orbits are getting populated right now at 610 or so and above. And most of the Starlinks are at 560 and below. So there's this area that we could stay in, except there's a lot of other regulations about de-orbiting over time.

[00:29:41.26] And just going through these huge numbers of satellites in these conjunctions that we're going to see over time. certainly the collision alerts everybody's really worried about, but it's really true. And we have put in new requests to the FCC to raise our orbits to be in the 575 kind of range, planet IQ.

[00:30:07.06] We've had six spacecraft. We've got several that are already de-orbited, and now we're launching more. But we wanted to be up in the higher orbits in these little areas that we're not really having so many conjunctions.

[00:30:20.68] One is do you have more comments about FX's orbit altitude regulations, and does it stay in the FCC, or is it really going to get pushed out? We've been seeing a lot of different things from rumors in the government. Who's going to manage orbit altitudes and orbital conjunctions, and does it really belong in the FCC or not? Anyway, we have active requests to the FCC about orbits right now to change the orbits that we have regulations to because we don't want to be in the Starlink's orbits.

[00:30:55.85] ANNA GOMEZ: Yeah. That's such a good question, and it's such a good setup for this entire conference. It is exactly what this conference is about, is how are we going to have a regulatory structure that ensures sustainable space use and how to work together?

[00:31:16.34] I would love to answer that specific question. But instead, I'm going to deflect to the panels that are coming up because I'm sure they have a better answer for it,. But it's exactly what I think we're going to be talking about.

[00:31:26.57] BRAD BERNTHAL: Well, it's kind of you not to preempt the 11 o'clock panel that's coming on board that will discuss that. Very appreciated. We are about at time. Do you have time for one more question before we adjourn? All right. Last question.

[00:31:38.92] ANNA GOMEZ: Something easy, please.

[00:31:40.03] BRAD BERNTHAL: Let's go up here. Yep.

[00:31:46.93] AUDIENCE: Good morning. What would you say are the space races of today, and what opportunities would drive more immediate actions?

[00:31:56.20] ANNA GOMEZ: Wow. I said easy. Well, I think-- global? I think the low Earth orbit NGSO, small satellites is really a race right now. It's both domestically from a competitive standpoint as well as China, which is itself very aggressively trying to get in this field, whether it complies with rules or not. So that's one.

[00:32:30.21] I think very interesting is lunar communications. I don't know if that's a race. But I think it's looking at what's really beyond just us and how we're going to handle communications. So I think that's very interesting. I think space in general is really the seriously the sexy thing today. So it's all a race.

[00:33:03.54] BRAD BERNTHAL: It is always a treat to have you back here at Silicon Flatirons. And you have delivered a thoughtful, substantive keynote to get us off on the good foot. Please help me thank Commissioner Gomez.

Panel: Resolving Spectrum Conflicts Between Active Users in Space and on Earth

https://youtu.be/UcwJasjjph0?si=0CLyUYjJfZIyRrL5

[00:00:01.01] PETER TENHULA: Hello, hello. My name is Peter Tenhula, senior fellow at Silicon Flatirons Spectrum Policy Initiative. Pleased to introduce this first panel, the kick off panel. Of course, we have to kick off with spectrum, and we got a superstar panel to do that for you.

[00:00:21.63] I'll introduce the moderator, Julie Kearney, and then she'll introduce the other panels. I'll note a change in the program. Unfortunately, we had a last minute change. As of Sunday, General Shelton had a death in the family and notified us as soon as he could. And we have a wonderful substitute in his place. Maybe can't fill his shoes, but we'll try with Rich Lee, Silicon Flatirons supporter. But we appreciate Rich stepping up

[00:00:54.38] Our moderator. And also hopefully, you can pitch hit as a panelist too because of her great substantive knowledge in this area is Julie Kearney. Julie is currently a partner and co-chair of the Space Exploration and Innovation Practice at DLA Piper, also a strong Silicon Flatirons supporter.

[00:01:15.96] She was the first inaugural chief of the FCC's new Space Bureau, most recently before she left government service to the private sector. I welcome Julie and her panelists and let her kick it off, and we'll be open for Q&A around 10:35 with a student question.

[00:01:39.21] JULIE KEARNEY: Fantastic.

[00:01:39.53] PETER TENHULA: Looking forward to hearing their stuff.

[00:01:42.22] JULIE KEARNEY: Great. Thank you so much, Peter. Thank you to Silicon Flatirons for having me join today. I have always had this coming out to Boulder on my bucket list, and I'm delighted to be here. So also really proud to have DLA Piper as a strong supporter. We have some very illustrious alums on the staff at DLA Piper. So thank you, Silicon Flatirons.

[00:02:06.00] Thank you, Commissioner Gomez, for your wise remarks. As Peter noted, I'm Julie Carney. And I'll give you a quick background about myself. I'm going to have our illustrious panel introduce themselves, but just wanted to set the stage a little bit. I had a wonderful time at the commission leading the Space Bureau for two years.

[00:02:26.41] And before that, I worked at Alphabet, which was launching balloons into the stratosphere at a company called Loon to deliver internet to parts of the world that were unserved. And that I call my space balloon lawyer phase. And it really set me up well to

understand the needs for spectrum to be wisely allocated, but also ensuring that we're using spectrum in the most efficient way possible.

[00:02:55.48] So as we start, I want to give you a few stats from the 2025 Satellite Industry report. And the massive growth in space services has really fueled demand for scarce spectrum in the US and globally. So for some perspective, at the end of 2024, a total of 11,539 satellites were operating in Earth orbit, compared to just 3,37 inches 2020. That's a lot.

[00:03:28.72] The FCC, for its part, has been doing a lot to alleviate the spectrum crunch and to make more spectrum available for space services. So 2024, in September, at the commission meeting with the of Commissioner Gomez and fellow commissioners, FCC took a big step toward the future of space by opening gigahertz for shared use by satellite systems in geostationary and non-geostationary orbits. Yay. November 2024, adopted new rules to support competition and cooperation in spectrum usage by satellite systems for non-geostationary satellite orbit fixed satellite service spectrum sharing.

[00:04:14.81] So that's NGSO FSS So you get a lesson in acronyms today. Also authorized more spectrum for space launches. And just recently, again with Commissioner Gomez's support, unlocking 20,000 megahertz of spectrum. And there is currently a notice and proposed rulemaking out for that. So really exciting times.

[00:04:38.81] And with that, we're going to dig a lot deeper into the FCC and the World Radiocommunication Conference. But I want to turn it over to the panel and do some self introductions. We'll start with Tom. We'll go to Kim, and then we'll go to Rich. We're so grateful that you're here today. General Shelton was, unfortunately, as you heard from Peter, unable to join. But because he is very organized, he actually had a person come in and join us. So really excited to have him here today. But I'm going to turn it over to Tom DOMBROWSKY at T-Mobile.

[00:05:12.02] THOMAS DOMBROWSKY: Hi. Good morning, everybody. Happy to be here. I'm Tom Dombrowsky. I know the bios in there, but you probably are wondering why is there a terrestrial mobile guy at a satellite conference? But in case you guys haven't been reading the news, as of yesterday, we at T-Mobile announced the commercial launch of our Starlink partnership for the satellite program. It'll begin July 23 with SMS and MMS in the Android products. And then by October 1, we'll have skinny data, as we call it, so certain optimized applications will be available from satellite.

[00:05:46.67] T-Mobile has always looked at ways to innovate, whether it's in terrestrial use of spectrum or satellite use of spectrum. And really we always talk about customer love and what can we do to make our customers happy. And we look at the satellite realm as the next

environment for us to innovate in and to deliver service to customers where they're not able to get terrestrial service.

[00:06:08.76] And our partnership with Starlink is allowing us to move forward with that and use the actual devices that everybody already has. You don't have to replace your device. You don't have to do anything fancy from a customer standpoint, from an engineering standpoint, all we're really doing is adding it to our roaming list, and you're just roaming to a base station that happens to be hundreds of miles up in space, instead of a few miles from where you're actually trying to communicate with.

[00:06:32.46] So I'm very excited to be here today and look forward to discussing all these issues with everyone here today on the panel.

[00:06:39.80] JULIE KEARNEY: Great. And Kim.

[00:06:41.37] KIMBERLY BAUM: OK. Good morning, everyone. My name is Kim Baum. I started my career at the FCC as an electronics engineer, and it was a wonderful experience. In just a few small years, I was at World Radiocommunications Conference representing the United States. So it was really a wonderful experience that I don't think I would have had elsewhere.

[00:07:05.88] Since then, I've had held a number of regulatory positions at Motorola, multiple satellite companies, including SES, most recently OneWeb, and now I'm with Astranis. And Astranis, as Anna had mentioned in her keynote, is manufacturing small geostationary satellites in California. And we're taking an innovative approach where we build smaller satellites that are designed to serve a particular customer's needs.

[00:07:40.17] So we're able to do that much faster than a traditional, like large geostationary satellite. So on the order of 18 months instead of four years. So while I think you'll hear a lot today about exciting things happening in the non-geostationary space, we would argue that there's a lot of exciting things happening in the geostationary space as well.

[00:08:03.59] And I think the focus on LEO and low Earth orbit, is forcing us and the geostationary orbit to look at new ways of filling the needs of customers who may want a specialized solution instead of a large global company serving their interest.

[00:08:23.60] And we have five satellites in orbit today, and we have customers all around the world, Apco in Mexico, and [? Anuvu ?] here in the United States, Orbitz in the Philippines, [INAUDIBLE] in Taiwan, and even other satellite operators like Thaicom. So I'm excited to be here and talk more about space.

[00:08:46.21] JULIE KEARNEY: Thank you. Our favorite subject.

[00:08:48.26] KIMBERLY BAUM: Yes.

[00:08:49.48] JULIE KEARNEY: Rich?

[00:08:50.57] RICH LEE: Thank you. Good sound check. I'm Rich Lee. I'm CEO of a startup that started here at CU called [INAUDIBLE]. We focused on PNT. And one of my heroes in the industry who I'm taking the place of today. JULIE KEARNEY: What is PNT? RICH LEE: PNT, position, navigation, and time. Thank you.

[00:09:13.13] JULIE KEARNEY: Thank you.

[00:09:14.47] RICH LEE: Acronyms.

[00:09:15.37] JULIE KEARNEY: Yes, yes.

[00:09:16.86] RICH LEE: I've been in the industry not quite as long as Dale Hatfield, about 50 years. I started my career at Motorola, which back then was one of the powerhouses. I've been in the cellular industry a long time. I also migrated into GPS, global positioning systems.

[00:09:37.04] And as many of you know, they're in virtually all the 6 billion or whatever it is global cell phones. Why GPS, though? What's the role of that? It's not only the position for 911, but it can be used for other advanced applications, which we're working with the DOD on in shared spectrum.

[00:10:02.34] We've got a great resource with the GPS, GNSS signals, and upcoming Astranas and other LEO signals. Act as a big MRI machine. These emit signals of great interest for sharing spectrum. I won't go into all the DBs and propagation analysis. That's why we have Dale here.

[00:10:27.54] But seriously, this is another new application for exploring how to better use our shared spectrum or our spectrum to share. And that goes for the public operators in the new emerging private 5G operators. Some of you-- a few like Al I thought I saw in the audience also know me to be on a board of a stealth LEO company. Believe me, it's not competing with anyone in this audience.

[00:10:57.49] It's got a unique mission, but it's to help bring new missions into research, to help research, to help commercial entities succeed with their communication or P|NT mission, position, navigation, and time. Did I use up my time?

[00:11:19.53] JULIE KEARNEY: No, no, please. I think we will spell out acronyms just for those of you who may be newer to the space, but I think what we'll do is we'll move into our panel. What you'll notice today, there are a lot of interesting views.

[00:11:34.21] And I think as you move, for those of you who are newer to the industry, you'll realize that there are a lot of use cases that fit into many different parts of our world. And we may not always agree with

each other, but we always go out for a drink after no matter where we are.

[00:11:52.27] And so what I find is interesting, as you mentioned, Tom, there's a terrestrial guy here. 10 years ago, could we have ever envisioned that we'd have this confluence of satellite and terrestrial the way that we're doing it today? But now let's move into the question that was sort of rhetorical, but let's move into some areas where I think it's going to get really interesting.

[00:12:16.50] I'm going to throw this out to the panel. What improvements in policies and regulations are required to better manage spectrum conflicts between multiple satellite and ground systems. And I'm going to kick it over to Tom.

[00:12:31.02] THOMAS DOMBROWSKY: Sure. Happy to address that as a starting point. So obviously, as I mentioned, we're now looking at having satellites deliver communications directly to cell phones on the ground. And as we talk about these low Earth orbiting satellites, you gotten much closer to the ground than we ever had with the geostationary orbit satellites.

[00:12:51.46] And because of that, more energy comes from the satellites and on the ground has to be managed more consistently to protect both co-channel operations, so the people that are operating on the same frequency as you are and those that are in the adjacent bands, and that adjacency and co-channel issue becomes a lot more complex when you think about how you mitigate those issues.

[00:13:11.80] So for a terrestrial guy, like me, we have base stations that maybe have one or two mile radius of circles around those that you have to protect against and worry about interference. When you're talking about satellites, you're talking about hundreds of miles of coordination that you have to do from one single transmission. So that makes things much more complex and complicated.

[00:13:31.27] And I think the big thing to think about in terms of how you manage that is how do we ensure what's coming from the satellite is actually managing to keep that power flux density, as the engineers would call it, at a manageable level that allows everybody to coexist? And everybody wants to use the spectrum more and more, whether it's satellite or terrestrial.

[00:13:51.83] And you have to really look at the engineering piece here. And it's gotten much more complex. As Julie mentioned, we've got 3x in the last five years in terms of the number of satellites we're trying to coordinate and figure out how to operate. It has made it much more complex and difficult to manage. I'll turn it to Kim to talk a little bit about how Astranas is doing it. But from the T-Mobile standpoint, we look at it in two different ways.

[00:14:17.06] So we have the mobile satellite service spectrum that has been traditional satellite spectrum delivery. So think Iridium, Globalstar, others of that nature that are just doing mobile satellite service to devices versus the supplemental communications from space, which Julie's team was nice enough to actually authorize in the last year or so. That's using terrestrial spectrum but from space in a supplementary basis, so that you have to protect the primary terrestrial users.

[00:14:47.64] So as you can imagine, from our perspective, the supplemental communications from space, we want to make sure our terrestrial co-channel operations are fully protected from any supplementary use from space. On the mobile satellite service side, they have dedicated spectrum. So it's really not a co-channel issue necessarily. It's more of an adjacent channel issue. So I'll turn to Kim because they actually build satellites and I don't maybe she can talk a little bit about how they're trying to manage that.

[00:15:12.90] JULIE KEARNEY: And I was wondering too, if you might even want to talk about how the US currently licenses since you've been on all Kim was former FCC, so you were on both sides, as you mentioned. But how we license in the US. And to continue with the thread that Tom started.

[00:15:29.70] KIMBERLY BAUM: OK, thank you, Julie and Tom. So the FCC for satellites to some extent has two different licensing regimes on the GSO side. Satellites share the same spectrum by being separated in the geostationary satellite orbit and meeting certain technical rules.

[00:15:50.16] So typically, we have geostationary satellites using, say, ku-band frequencies like every two degrees. Band is roughly frequencies from 11 to gigahertz. There will be a test. Yes, yes. And then on the NGSO side, which include systems like what Tom talked about MSAs, the FCC holds processing rounds and seeks interest from everyone that wants to use a given frequency band at the same time.

[00:16:24.54] And in some cases, depending on the terminal type, the FCC may license just one system in a given set of frequencies. But if you look at SpaceX, OneWeb Kuiper the FCC is licensing multiple systems in the same spectrum and largely leaving it to those systems to figure out, how they share.

[00:16:46.92] But since I'm a GSO operator, I'll talk a little bit more about geostationary licensing. So for rights at a given orbit location, the FCC has a first come, first serve process. So the first entity that files, essentially gets the orbit location.

[00:17:08.32] And what we see as a relative newcomer to this environment is that you have established GSO, geostationary satellite orbit companies that have a lot of satellites. So like old satellites or they have satellites where they've put on small payloads that aren't really

commercially viable, but they're sufficient for getting a license to use the spectrum.

[00:17:33.64] So these companies, by moving an old satellite to a new orbit location or putting additional mini payloads on a satellite, are able to get a license to use the spectrum for 15 years. And also, they're able to avoid some of the FCC's requirements for putting up a surety bond because they already have the satellite in space. You don't have to put up a bond to maintain those rights. So that creates difficulties for newcomers getting access to spectrum.

[00:18:09.34] And so we would like to see the commission look at what's in the public interest. Is it continuing to license, payloads that can't provide commercial services or these older satellites that aren't really capable of providing commercial service, or if it would be better to open up to New companies to provide service. So that's one issue I wanted to highlight today.

[00:18:32.80] JULIE KEARNEY: Question. How do you think improvements in the process could help companies? What types of improvements do you think would be helpful? Or more spectrum.

[00:18:45.11] [LAUGHS]

[00:18:46.24] THOMAS DOMBROWSKY: Yeah. Well, I'll address that first.

[00:18:48.44] JULIE KEARNEY: And I don't want to leave rich out of it.

[00:18:49.67] THOMAS DOMBROWSKY: Yeah.

[00:18:49.91] JULIE KEARNEY: We'll get to Rich.

[00:18:50.84]

[00:18:51.01] THOMAS DOMBROWSKY: Yeah. So on the geostationary side, I mean, as Kim said, you get orbital slot. You get a certain set of frequencies that are there. If you look at that, they typically have a degree separation. So 3 or 6 degree separation between these geostationary orbital slots. If you could shrink that with better antennas and better capabilities, maybe that's the way you can get better reuse of the spectrum. That's what we have to do on the terrestrial environment all the time.

[00:19:16.91] However, again, going back, we're coming from space, so it makes it a lot more complex than it is to manage on the terrestrial side. On the non-geostationary orbit side, I think from my perspective, as you look at where we're headed and where things are going, parties continue to file again and again in these processing rounds and force a process there, regardless of whether somebody before was using the spectrum, or whether that party would maybe have a desire to move to a non-geostationary orbit operation.

[00:19:49.34] So a of cases, folks, that are targeting the new NGSO, non-geostationary low Earth orbiting satellite systems are looking at geostationary orbital systems and seeing, hey, can I share with those guys, or can I piggyback on top of them, or can I get some of the spectrum they're using? So if we look at that more broadly, I think it would be helpful to drive more use of the spectrum of the existing spectrum assets.

[00:20:17.15] So again, as everybody knows, things are getting more and more crowded there, whether it's space or spectrum. And any way we can get more efficiency and more effective use of things has got to be something we should focus on.

[00:20:29.40] JULIE KEARNEY: Thanks, Tom. Rich, we're going to kick it over to you and hear your deep thoughts.

[00:20:35.51] RICH LEE: Well, I'm going to use a prerogative here. I'm going to ask the panel here. How many SATcomm operators do we need? Is that talked about at all? How many folks need to be up there? And there's different places. There's a wholesale play, there's backhaul, there's various kinds of retail.

[00:21:00.30] And Tom's approach here of having with [? TIMO ?] Very interesting compliment for not only coverage but perhaps emergency and other new applications, IoT applications. But how many different operators do we need?

[00:21:19.93] I know from my scan of the PNT with General Shelton and others, there are about 11 internationally with the US focused on PNT possibly by doing combat. many folks, how many companies need to be engaged in this and remain competitive.

[00:21:42.96] KIMBERLY BAUM: I work for a law firm, so lots.

[00:21:45.09] [LAUGHTER]

[00:21:47.08] All of them.

[00:21:48.57] THOMAS DOMBROWSKY: And my perspective on that is let competition decide how many there should be. We always say 1,000 flowers bloom, and then see which one ends up there. If you need 10, you have 10. If you need five, you get five. It usually comes to equilibrium at some point. So I think anytime you try and guess what the right number is, you're doomed to failure, at least from my perspective.

[00:22:12.18] KIMBERLY BAUM: And I think, though, as you see a shift towards NGSO operators, there's a lot of consolidation in the satellite industry going on to try to compete, I think. But I think because of that consolidation, it's critical to be looking at ways of ensuring the spectrum is being used efficiently, being sure there are opportunities for newcomers to acquire spectrum.

[00:22:37.03] JULIE KEARNEY: And I think Commissioner Gomez talked about her recent trip to California. And I've done a lot of those trips as well. And it's incredible to see the innovations that are coming. And you have to wonder what is the limiting factor. Is it spectrum? Is it access to capital? What is it?

[00:22:56.73] I don't think we're there yet. I think we're still in that phase where people are continuing to innovate. And I'll go back to Tom where competition is really going to sort out where we ultimately end up. But it's an exciting place to be. Did you have anything else you wanted to add on the regulatory?

[00:23:18.05] RICH LEE: I'm trying to draw from the rest of the panel expertise.

[00:23:21.59] JULIE KEARNEY: OK, great. Well, we'll continue to draw from the panel. Let's go to the World Radiocommunication Conference '27. And the question for the panel is, how can ex-ante spectrum allocation disputes be peacefully resolved ahead of the World Radiocommunication Conference.

[00:23:39.29] THOMAS DOMBROWSKY: As the non-lawyer, can you explain what ex-ante means? It's Latin, I think, or something.

[00:23:44.27] THOMAS DOMBROWSKY: Ex-ante is beforehand. What can we solve before regulations are established? And I'll do a little bit of discussion here really quickly of the World Radiocommunication Conference. This is the work-- the International Telecommunication Union in Geneva is the international body, where pretty much every country in the world is a member.

[00:24:07.04] And they have a World Radiocommunication Conference, a global inter-governmental treaty conference every four years. And right now we're trying to figure out where it is going to be in 2027. The US has just thrown its hat into the ring. It might be Geneva. It originally supposed to be Shanghai. And potentially I think Africa was in the running as well. So this almost seems like the Olympics. But apparently, the US threw its hat into the ring today.

[00:24:35.15] The most recent WRC happened in Dubai in December of 2023. And delegates updated the world's Radio Regulations. Kim, you were there. Many of the people in this room were there. The Radio Regulations that's the treaty that governs the allocation and use of radio frequency spectrum and satellite orbital locations. And it was five weeks long and people are still recovering. The work has actually started for 2027.

[00:25:04.66] But back to WRC. It's how we globalize this scarce spectrum resources to support the communications that we use in everyday life. So 80%, as Commissioner Gomez mentioned, 80% of the items are space related. So we are informally calling it the space WRC. It is unprecedented to have so many space related items.

[00:25:29.12] Kim, give us a little. Bit talk about how are some of the things that are coming up in the upcoming World Radiocommunication Conference? How might we peacefully resolve some of those things ahead of time? But feel free to meander.

[00:25:44.21] KIMBERLY BAUM: OK. Well, thank you, Julie. I mean, it's really an interesting agenda. Each conference has a set list of agenda items that they're supposed to work on. And as has been said, there's a huge number of space agenda items for this WRC.

[00:26:02.99] And if you look at those, there's an interesting tension. There's a number of agenda items that are intended to facilitate or enable these new type of NGSO systems that we're seeing coming online. But there's also a reaction to those systems, to those global systems that you see in other agenda items.

[00:26:28.07] So I think other countries are concerned about these large global systems that are being built essentially by the United States. And so their agenda items looking at equitable access, looking at potential planning or other means to ensure access by other countries.

[00:26:51.02] JULIE KEARNEY: Can you talk a little more about the equitable access thing? Because I think that's really interesting, and then we'll put a pin in.

[00:26:58.57] KIMBERLY BAUM: So for a long time in the ITU, and I guess in the world at large, there's been a real tension between those who have space activities or satellites already and those who don't.

[00:27:12.66] JULIE KEARNEY: A lot of developing world versus developed.

[00:27:16.84] KIMBERLY BAUM: Yes. And to deal with that and to enable countries like the United States to continue to build and operate satellites, over the years, the ITU has come up with different approaches. But the first approach to address equitable access was developing plans in the 1970s and 1980s that would set aside frequencies--

[00:27:44.54] JULIE KEARNEY: At a disco. That's a whole--

[00:27:47.05] KIMBERLY BAUM: Yes, yes.

[00:27:48.04] THOMAS DOMBROWSKY: --second act.

[00:27:48.99] KIMBERLY BAUM: So the plan would set aside a given orbit location and frequencies for Rwanda. And that plan assignment would be there forever for them for when they chose to use it. So that was one mechanism that was used. But then you have to enable means for real systems to build around those plant assignments and actually be implemented.

[00:28:14.60] And systems that operate in the plant bands for a long time are like DirecTV and dish like in the BSS plan band. So some countries like seeing SpaceX and Kuiper and these big global systems are looking for additional plans, perhaps in Q/V band frequencies like from 37 to about 51 gigahertz So you see a push towards global systems and making them more possible, and then you're pulling back, and each country wants to still have access to space and spectrum.

[00:28:49.75] THOMAS DOMBROWSKY: And we want them to. But it is that tension. What can we settle? Where do we go now between now and 2027? And will we ever resolve these very difficult questions? I think, Kim, maybe if there are any other items that are happening at the WRC, you think that would be interesting to talk about these EPFD limits or directed device issues or lunar? Are there some things maybe we want to talk to the crowd about?

[00:29:23.25] KIMBERLY BAUM: Yes.

[00:29:24.16] JULIE KEARNEY: And weigh in please others.

[00:29:25.75] KIMBERLY BAUM: EPFD, equivalent power flux density limits. It's a sharing regime that was developed in the late '90s and finalized at what, 2000 for non-geostationary systems to protect geostationary systems and enable these NGSO systems to use the same frequency bands without having to go around the world and coordinate with every single geostationary satellite system. So it was really intended to enable NGSO systems.

[00:29:55.82] But those systems that were envisioned at the time weren't implemented. I don't know if folks remember Skybridge or Teledesic or those systems. And instead, we're here 20-some years later and we have very different looking systems with many thousands of satellites instead of 100.

[00:30:16.35] And so it was there was a big push by the United States to have an agenda item for [? Work ?] '27 to look at revising those EPFD limits, because they were becoming very constraining on the NGSO systems. But because of some of those tensions that I talked about, the US couldn't reach an agreement with all these other countries to have an agenda item.

[00:30:39.66] So instead, there's text that technical study should be done, and those should be reported back to the WRC with no regulatory consequences. So here in the US, given this big push, the FCC has issued a notice of proposed rulemaking or an NPRM looking at changing those EPFD limits, at least on United States territory to give more flexibility for NGSO systems while still protecting GSOs.

[00:31:12.77] So I think that's one way, Julie, where the US is looking at paving the way, or starting the discussions here while continuing to work on those technical studies on an international basis.

[00:31:27.06] JULIE KEARNEY: Yeah. And I think-- Tom, did you have something? Thank you, Kim.

[00:31:30.71] THOMAS DOMBROWSKY: I'll talk to direct the vice, but finish this topic first.

[00:31:33.42] JULIE KEARNEY: Yeah, I think that is definitely something with the EPFD limits, where we have two different groups in the US for and against, and how it will inform, how what happens in the US regulatory process will inform what happens at the World Radiocommunication Conference in whatever country it happens to be in 2027.

[00:31:55.95] THOMAS DOMBROWSKY: Yeah. And just finish off on that. I mean, I think the other interesting thing is it's not just NGSO, non-geostationary to geostationary, it's also other NGSO have different perspectives depending on how their satellites are configured and all that.

[00:32:09.64] So that makes this problem that much more complex. And it's good that we're spending the time to dig into this well in advance of the World Radio Conference. But if I can shift gears to direct.

[00:32:21.27] JULIE KEARNEY: Please, yes.

[00:32:21.61] THOMAS DOMBROWSKY: So as Kim said, they have agenda items here some of which are satellite related. The one that's of interest to T-Mobile is agenda item 1.13. What that's looking at is the direct device issue and how do they do that. And they're looking at the 698 to 2700 megahertz band and suggesting, how do we take that terrestrial spectrum and have satellite use of that band while still protecting the terrestrial use.

[00:32:47.19] From a terrestrial mobile operator's perspective, We believe that band is a terrestrial mobile band, and it should be primarily for terrestrial mobile services. Other countries and other parties have slightly different opinions about that. Maybe they want to be primary in their particular country for that particular spectrum band or not.

[00:33:05.77] But from a mobile operator standpoint, we think it's very important that any terrestrial and it's International Mobile Telephone specification, IMT, is the other acronym they use there. Any IMT spectrum is still primary terrestrial. And if the terrestrial operator wants to use it to help supplement with satellite, that that should be secondary to the terrestrial operation.

[00:33:28.00] So there's a lot of debate and discussion about how do you make that happen, how do you protect the terrestrial operations, how do you implement all these satellite systems so that you don't cause problems to the co-channel terrestrial operators, as well as any adjacent operators.

[00:33:41.95] So as you remember my earlier comments that it gets very complex when you're talking about operating from space. So it'll be a pretty heavily argued argument there, I think. I don't know what you think, Kim, but I think that one's going to be a lot of fireworks.

[00:33:57.43] KIMBERLY BAUM: Yes, definitely. And I think, again, because the US is out ahead on implementing this, that causes some pushback, I think, from other countries. And it's also an interesting discussion about operations under radio regulation 4.4 where you don't have an allocation. There's this one provision in the radio regulations that you operate under. So those discussions are interrelated as well and quite contentious.

[00:34:28.16] JULIE KEARNEY: Well, and it's really interesting as well. So the US we have regulations in the first license was issued to operate for T-Mobile and SpaceX their Starlink service. Where the US came out with rules, has issued licenses. Canada is in the process. They've now issued their framework. They haven't issued any licenses yet.

[00:34:51.35] But you have a lot of countries who are looking what has worked, what have you learned operating within the confines of the 4.4. But this is again, it's like a chicken and an egg. Will we have more global uptake? How will that impact WRC discussion?

[00:35:12.78] THOMAS DOMBROWSKY: Yeah, I'm not sure how to impact WRC, but I think in our case, we actually took terrestrial spectrum, 10 megahertz of spectrum and dedicated a lot of it towards the supplementary communications from space. The reason why a lot of other parties in other countries haven't gotten there yet is no one wants to take up very valuable terrestrial spectrum and migrate it over to satellite use.

[00:35:33.15] We saw a need, and we were actually stepping up, and we're still using it for terrestrial, but also using it for satellite. So I think the number one problem, as always, is how do we get more spectrum, and how do we use it more efficiently? Secondarily, we have the mobile satellite service that's out there and being used as a standalone service. A lot of those folks would love to integrate that into the same way that we've done it, but the problem being we use terrestrial spectrum so it's already in the mobile device.

[00:36:00.99] The MSS spectrum, the mobile satellite service spectrum with the exception of all the work Apple and Globalstar have done is not resident in your normal mobile device. So that's another barrier to entry that we have to get over as well as how do you see those devices, how do you make sure they operate peacefully with the rest of your terrestrial operations as well.

[00:36:21.96] JULIE KEARNEY: Yeah. And oh, yes. Rich, please.

[00:36:25.31] RICH LEE: I'm going to draw on the expertise again, but Tom and Kim, is there any move afoot over the next few years to

increasingly modify the user device to make it more satellite compatible, close the link, as it's called, for higher bandwidth than say, just text?

[00:36:44.66] THOMAS DOMBROWSKY: I think most of the work is on the satellite side more than the mobile side. So obviously, we've gone from geostationary, which is tens of thousands of miles up in space, down to hundreds of miles in space. So that's helped close the link dramatically. That's what's made this service possible as we've closed it that way.

[00:37:01.09] And I think they're looking-- I mean, Jennifer Manor will be on a later panel. AST has got a much higher power antenna that they want to use for their service. So a lot of the innovation is on the satellite side, more on the mobile side.

[00:37:12.97] But yes, I will say without giving away company secrets, we're certainly looking at how we can optimize the customer experience from the mobile backup to the satellite as well. But I wouldn't say there's going to be fundamental changes to the mobile device to close that link.

[00:37:27.19] JULIE KEARNEY: Well, and I think to Tom's point too, you want to have as much penetration in the market with people who have the devices in hand already so to have that ubiquity as you're continuing to deploy the service.

[00:37:41.13] THOMAS DOMBROWSKY: Right. I mean, it's just like any other sort of technology transition. You want to have the devices ceded to people before you turn on the service. And they say, hey, it doesn't operate like you said it was going to. And it's like, well, you have an old device. You need the new device. And customers don't really like buying new devices. I don't know why. I highly recommend you buy new devices. It'd be great for our company.

[00:38:04.14] JULIE KEARNEY: And then I had another couple issues to add. Did you have anything else you wanted to add, Rich.

[00:38:08.34] RICH LEE: That's fine. Lunar and state-based sustainability. I don't know if we want to talk about that here if we're comfortable going into that. But there are, of course, lunar items with the prevalence of lunar communications.

[00:38:21.75] I know we have people here. I see Jennifer Warren and others who are working on services that are going to be lunar based. Very exciting. Did we have anything we wanted to talk about there or base sustainability? We all want to protect space. Yes.

[00:38:37.41] KIMBERLY BAUM: So on lunar, certainly, there's an agenda item. A number of frequency bands have been identified to look at studies of how we can enable use of these bands on the lunar surface and for communications to the surface the orbits around the moon. I think one of the key questions, and, of course, Jennifer is much

more of an expert on this than is looking at this from a definitional perspective within the radio regulations.

[00:39:12.85] Now, you would just have to call any operation on the moon like a space station. But to truly categorize it separately, I think, there needs to be some more definition of terms. But I think it's certainly exciting to see the spectrum world keeping pace with this exciting time getting back to the moon.

[00:39:33.64] THOMAS DOMBROWSKY: And I think the other thing is just like any other spectrum battle, when you start to do new services, you typically look at spectrum that's being used for other services. So making sure that as you move towards lunar that you're protecting existing incumbents as well is another tricky part of that effort as well.

[00:39:51.65] JULIE KEARNEY: Yeah, absolutely. OK, now we're going to move on to the next question. What is the role and reliability of Ex-Post, eg., monitoring and enforcement to ensure interference, free coexistence among in-band and out-of-band users in space and on the ground? I know Tom and Rich have lots to say here.

[00:40:16.55] [LAUGHS]

[00:40:19.57] Is it OK to say deportation? No, but--

[00:40:22.98] JULIE KEARNEY: [LAUGHS]

[00:40:24.43] RICH LEE: That is going to be interesting. But smart folks like Tom and Kim are going to I'm sure design more software defined radio systems and intelligent beamforming. And this medium is really making interference resolution as densities grow, of course, easier to resolve, I think. Would you agree? Put it back to you.

[00:40:59.18] THOMAS DOMBROWSKY: Yeah. I mean, I'll talk a little bit about interference resolution. I mean, monitoring and enforcement. I was playing of playing off of Commissioner Gomez's comments about the cutbacks in the government. Realistically, we would not expect the government to continue to grow. And in that case, how does the government monitor and enforce?

[00:41:17.61] And I think what we've seen in the past 30 to 40 years at the FCC is a recognition that there is an ability to privatize monitoring and enforcement. They have frequency advisory groups that do actual frequency coordination ahead of time. They've privatized the certification of equipment. So most equipment is done by a third party, not by the FCC.

[00:41:40.45] I think similar things could be done on the monitoring and enforcement side On the satellite realm as well as on the mobile realm. And I think that's something we need to be really looking at very closely, number one. Number two, I will say-- and I'm former FCC, so I'll never say anything bad about the FCC.

[00:41:59.44] But what you'll see with FCC is they're extremely conservative when they do a first decision. And to Rich's point, as we're getting smarter and smarter equipment, the need for really conservative first assumptions doesn't make any sense to me anymore. I think you need to let the folks get out there and innovate and cause problems and resolve it on their own.

[00:42:21.45] I was at the FCC 30 years ago, and we got yelled at because we were allowing this personal communications service to happen. And we weren't really regulating it like we did the cellular service, and everybody told us it would be a disaster. Question, does anybody not have a smartphone right now? Did it turn out OK? I think it turned out OK. I think we managed.

[00:42:40.30] JULIE KEARNEY: Turned out too well.

[00:42:41.45] THOMAS DOMBROWSKY: Yeah. Hey, no no.

[00:42:42.79] JULIE KEARNEY: No, never [INAUDIBLE].

[00:42:44.27] THOMAS DOMBROWSKY: Never too well. So I think there needs to be a recognition that the government certainly has a role here given the diminished resources they have there. And the speed at which the industry is moving, the need for some privatization and less conservative first assumptions when they actually authorize services.

[00:43:04.33] I'll leave the last point on that. Generally, they're so conservative, you don't see a lot of interference complaints after an FCC decision. And there's a reason for that. They've belt and suspenders it so tightly, the idea that there would be an interference problem is beyond the pale from an engineering standpoint. And I would argue, given the scarcity of spectrum, that you need to push the envelope a little bit on that in order to actually get more use out of the spectrum.

[00:43:31.18] KIMBERLY BAUM: I want to say it's the incredible talent working on the issues at the FCC.

[00:43:37.93] THOMAS DOMBROWSKY: Absolutely.

[00:43:38.86] JULIE KEARNEY: And our stakeholders-- their stakeholders. Kim, did you have something you wanted to add?

[00:43:43.76] KIMBERLY BAUM: Well, I guess if you look back at the EPFD question that we had addressed earlier. The FCC had turned from looking at the EPFD analysis itself to relying on the ITU's finding that the epbd limits were met. So I think as we're looking into what do we replace the EPFD limits with, there's one question is, what criteria should that be?

[00:44:09.62] And I think some of the criteria is fairly extreme noting that Tom mentioned belt and suspenders. But looking at changes in

absolute availability like on the order of 3% could have a significant impact to other systems. But there's also a question is who's going to determine if those things are met? Is it the FCC? Is it going to be individual systems? But there should be a means for others to comment on analysis to help ensure compliance.

[00:44:41.12] THOMAS DOMBROWSKY: Yeah. No, I agree with that. I think the SEC has a very strong auditor role of these things. And it's what they do on the equipment authorization process as they set out a guideline. If it's met, the third party can go forward.

[00:44:53.09] If they have questions, they go immediately to the FCC and say, I have questions. I don't know how to do this. This is something new. This is something novel. I'm not sure how I should handle it. And the FCC is the final arbiter of any sort of disputes or questions, and I think it could work in other contexts as well. Go ahead, Rich.

[00:45:09.04] RICH LEE: Well, one thing I wanted to add, and I was sensitized to this, Al visiting his lab earlier last week I guess it was out from CU, He's doing tremendous research with his students and environmental systems and Sciences.

[00:45:29.21] And one of the questions earlier to Commissioner Gomez touched on is, could we see formalizing in the regulatory process? As we're growing these ecosystems, formalize the role of environmental science? Who doesn't have the commercial power, if I'm using that term correctly. But the readiness to assert their needs in a way that rebalances this.

[00:46:02.64] We're also hearing about this around the world. Africa is going to have unique environmental science needs. The polar caps, et cetera, et cetera. It seems like we need to do something about that.

[00:46:26.84] JULIE KEARNEY: That's great. So let's move on to our next question. Shall we? OK. We may have answered this a bit, but we may have a little more to squeeze out of this fruit. How are new and innovative directed advice services and position, navigation, and timing services being accommodated under existing and modified spectrum management approaches?

[00:46:52.52] THOMAS DOMBROWSKY: Yeah, I feel like I've addressed this a couple of times, but I'm more than happy to talk about it again. So we have the supplemental communications from space ruling in the last year, which we're launching our service with, where you're repurposing terrestrial spectrum on a secondary basis doing satellite communications.

[00:47:10.02] We also have the mobile satellite service that has dedicated spectrum that's just for satellite use. And I think a lot of those were started out with geostationary orbit satellites, or maybe as

they called them, big LEOs, which I've never understood what was big about them. Maybe it was big satellites.

[00:47:26.12] But nowhere near the number of satellites that we're seeing now for the low Earth orbiting satellites. So I think we're seeing a growth in both areas. I think what's still left to be seen is, is there a way to merge these. So that works well for both, or is it going to always stay bifurcated, and is that the best way to do that?

[00:47:50.86] And then the final piece is something I already mentioned before too which is how do you make sure it's in the device? So mobile satellite service spectrum is not in your device now with the exception of the Globalstar Apple spectrum. So how do you get that into the device and do it in a cost effective way and seed the environment with that kind of capability quickly and seamlessly so the customer doesn't know what's going on?

[00:48:15.60] JULIE KEARNEY: OK. Any other additions? I think we're nearing in on our Q&A, unless we have any more inputs from our panel. OK, I think we have 16 minutes left. We don't have to use every minute. We can get you to coffee. But let's open the floor to a student. Yes. And if you could tell us who you are, that would be great for the panel. Did you have a question? Not a student. OK. Do we have any student questions? OK, you are up.

[00:48:58.54] STUDENT: Hi. Yeah. Thank you very much for this panel. It was very informative. Quick question regarding the supplemental coverage from space that operates in the US under Regulation 4.4. I was wondering if we've had already issues of interference with neighboring countries? And if we had not, what is the plan for conflict resolution if it were to happen?

[00:49:26.75] JULIE KEARNEY: So I'm currently not aware of any. I'll let Tom know. And where are you from, may we ask?

[00:49:33.32] STUDENT: Oh, sorry. Caltech. California Institute of Technology.

[00:49:35.35] JULIE KEARNEY: Oh, great. Wonderful. Yay, California.

[00:49:37.06] STUDENT: I'm another undercover astrophysicist.

[00:49:39.97] JULIE KEARNEY: Oh, great.

[00:49:40.55] [LAUGHS]

[00:49:42.31] Undercover.

[00:49:42.74] THOMAS DOMBROWSKY: I think we have the benefit in the US of having a Mexico and Canada border that we have to worry about. We don't have 30 or 40 borders to manage. Especially with satellite work could get that much more complex. We're using our PCSG block, which is 1910 to 1915 megahertz paired with 1990 to

1995 megahertz. Mexico doesn't have a licensee there, so there's no one to interfere with.

[00:50:08.14] In Canada, there's licensees, but we have a back off from the Canadian border. We've been working to negotiate both areas around the border for both Canada and Mexico, but no interference issues have arisen and obviously couldn't with Mexico, because there's not an operator that we could actually be interfering with.

[00:50:31.17] JULIE KEARNEY: Any other questions from the floor? Yes, we have another question.

[00:50:37.41] PETER TENHULA: This will be an odd question, and it will be crucial, I think. I'm taking off a little bit. I'm a humanities visitor from afar. The astrophysicists are sensitive. It's nothing to what the humanities are. But I think we're really useful. And where I am thinking so important our translators and interpreters.

[00:50:56.77] I'm responding a little bit to the acronym issue, but also to all the international negotiations. So if you have this very complicated technical field, and then you have a whole bunch of different countries speaking different languages, I'm just wondering would some of the tensions, conflicts, and so on turn out to be matters of misunderstanding?

[00:51:17.85] That having a whole team of maybe humanities people, who are always looking for employment, having them circulate at the world conferences and just as really carriers of messages, just noticing where mishaps of understanding are happening that maybe would that reduce the conflicts and the tensions significantly if those translators and interpreters were deployed.

[00:51:43.71] THOMAS DOMBROWSKY: Yeah, I'll go first, and I'll defer to the experts on this. But from my perspective, the arguments are not because they don't understand each other. The arguments are because they're competitors, whether it's country competitors or other things.

[00:51:56.16] And a lot of it's political, even more than just engineering. So I'm not sure the humanities would change it necessarily. I think maybe it'll make it even more obvious what we're arguing about. But I'll defer to the experts.

[00:52:08.84] KIMBERLY BAUM: So certainly, the ITU has very expert staff like interpreters. So I think when you're at a formal ITU meeting, the interpretation services are very reliable. But when we do go to meetings here in the Americas, like [INAUDIBLE], part of the Organization of American States, things are like lost in translation on the floor.

[00:52:34.30] And so I think, in those cases, more often side conversations happen to discuss issues. But then often the discussions

are in English because of the Americans. But so misunderstandings do happen, I think.

[00:52:50.35] JULIE KEARNEY: I think in any international setting, you have to go in with a bit of an open mind and patience and humanity. So music major here now, lawyer, part time engineer under supervision from engineers. But I do feel like we have a lot of very experienced people.

[00:53:11.83] And, ultimately, I think Tom said there's a competition among private sector and countries and everyone needs to be as transparent as possible. But, I think, ultimately, the translators do an amazing job. They translate into official six different languages. And I think they do amazingly well. Thank you. That's a great question. Oh, hey. Whoa OK. Where do we start? Is there a student?

[00:53:47.28] AUDIENCE: No students.

[00:53:47.70] JULIE KEARNEY: OK, No students. Following the wiser rule. I saw you first. Yes, if you could let us know who you are. Yes, gentleman with the hands up.

[00:53:58.92] AUIDENCE: Thank you. My name is Al [INAUDIBLE] and I work at CU here.

[00:54:01.66] JULIE KEARNEY: Wonderful. And I have a comment that builds on Commissioner Gomez's discussions earlier regarding agency, collaboration, cooperation, et ceter. And it has to do with the proposed rulemaking on spectrum abundance. That's now out for comments.

[00:54:22.51] One of the bands that was proposed for satellite uplink directly uses a current NOAA sounding band that's actually quite critical for weather forecasting. This is in the neighborhood of 50 gigahertz. I won't recite the precise frequencies, but you can look that up.

[00:54:45.11] JULIE KEARNEY: The 51.4 to 52.4.

[00:54:47.87] AUIDENCE: Yes, it falls directly into a band that's not only used by NOAA nationally, but by many other countries internationally for weather forecasting. And as we now know as a result of a number of studies over the years by ECMWF that have been corroborated by our own NCEP that these passive microwave bands provide something like 50% of the information content into our weather forecasts. And so with regard to interagency collaboration, I'm just wondering where it was that specific channel was somehow put up for consideration here.

[00:55:32.99] JULIE KEARNEY: That sounds like a great comment for you to submit in the notice of proposed rulemaking. But there is a NTIA is will work with NASA and NSF and others, including NOAA, if they decide to submit their own comments.

[00:55:50.31] THOMAS DOMBROWSKY: And I'll just note that it's not a decision. It's a proposal. And this is how the process works. If you never went after a band that there's an incumbent, we would never, ever have another FCC rulemaking. So they kick off these things. It goes through an NTIA process. NOAA is participatory in any NTIA process.

[00:56:09.47] When they get to an actual decision, your comment may be most appropriate. But I think the bottom line is they haven't actually made a decision on the ban yet, and it's one that's been kicking around for at least 15 years. I mean, we had pushed at one point for terrestrial mobile use of the ban too. So it's not a new idea. It's just something they've now teed up again.

[00:56:30.66] And it's part of the FCC process is they're going to ask questions, and they're going to force parties to provide technical detail as to what's going on the band, why it's critical, how it can be protected. And the answer cannot usually be just no. It can't just be no. It has to be here's why you need to protect me. Here's how you protect me and provide some sort of technical detail as to why you need to be protected and how.

[00:56:59.16] And the FCC does, as I said earlier, a very conservative job of protecting incumbents, generally. So I think through that process they'll get to the right answer, and they generally do. And if they don't, there's still another appeal process after that. So these processes go on and on and on, and there's always the opportunity for parties to present their opinions.

[00:57:17.05] JULIE KEARNEY: And can I note too. And thank you for the question, by the way. It's a great question. I'm quoting from the NPRM. This is not an opinion of me or any client. It says "these underused bands located in spectrum neighborhoods ideal for satellite broadband are prime candidates for modernization." And that's directly from the NPRM. So I think it'll be an interesting comment period.

[00:57:41.97] AUDIENCE: I will just point out that they are used, though, so I'm not sure about that word "underused."

[00:57:46.41] JULIE KEARNEY: Not my work. [LAUGHS] I wasn't there.

[00:57:50.02] KIMBERLY BAUM: And I would add--

[00:57:51.10] AUIDENCE: Thank you.

[00:57:51.64] JULIE KEARNEY: Thank you.

[00:57:52.21] KIMBERLY BAUM: One of the recent WRCs has dealt with this frequency band, so looked at sharing with other services, and so maybe some of those provisions can be relied upon. But I think this band has been looked at for satellite uplinks internationally already.

[00:58:09.21] JULIE KEARNEY: Yeah, I think it'll be interesting. We'll be looking forward to the comments. Thank you. Any other? Oh, yes.

[00:58:17.31] AUIDENCE: You're in charge.

[00:58:17.95] JULIE KEARNEY: You. Please. And if people could raise their hands? So we have two other questions. OK. Oh, my goodness. OK.

[00:58:28.23] AUIDENCE: My name is Dan Baker at CU. My understanding is that SpaceX has authorization for 42,000 more small satellites at low Earth orbit just for the Starlink kind of communications. What do market analysis suggest is going to be the number of satellites needed to service when everybody on Earth with a cell phone wants to use low Earth comms as well? And the panel.

[00:59:01.59] JULIE KEARNEY: I see [INAUDIBLE]

[00:59:02.76] THOMAS DOMBROWSKY: I see David [INAUDIBLE] up there. And he's going to talk later. You can ask that question. Because this is fun to throw it to David.

[00:59:10.69] JULIE KEARNEY: OK, hold that thought. We have SpaceX in the house. Yeah. I don't think any of us have anything we want to talk about. OK. Thank you.

[00:59:24.23] AUIDENCE: [INAUDIBLE]

[00:59:28.42] JULIE KEARNEY: OK, I see a hand here. Two or three questions at once. Put them up on the table. So we'll ask the questions of the three of you, and then we will whip through them. Thank you, Brad.

[00:59:40.11] AUIDENCE: [INAUDIBLE] from NTIA. I have a question about spectrum sharing. In terrestrial world, for almost 20 years we have been talking about dynamic spectrum sharing. As a matter of fact, me and Peter worked in shared spectrum company 20 years ago. We talked about dynamic spectrum access for so long.

[00:59:59.83] And now people are talking about AI, ML for spectrum management. But all of this is happening in the terrestrial world. I was wondering if there is any efforts of doing spectrum sharing between terrestrial and satellite networks doing kind of DSS type of thing, dynamic spectrum access, or DSS, dynamic spectrum sharing? Thank you.

[01:00:23.24] JULIE KEARNEY: OK, dynamic spectrum sharing. OK. Well, we'll knock it out.

[01:00:27.81] RICH LEE: Well I'll take a crack at it. So I think you're probably familiar with dynamic spectrum sharing and the initiatives there. And I personally believe that the satellite world could come into that in addition to terrestrial and in addition to deep incumbent

sharing, such as the DOD. And NTIA coordinating it, I think, there's a lot of spectrum that can be exploited there.

[01:00:59.33] THOMAS DOMBROWSKY: And in the future standards where 6G is certainly looking at how do we integrate satellite directly into the standard. And if we have the exact same standards mandated for both satellite and terrestrial use of the same spectrum, sharing becomes that much more easy.

[01:01:20.42] JULIE KEARNEY: OK, I saw a couple other hands. Yes, please. One minute.

[01:01:29.60] AUIDENCE: One minute. Kelsey Johnson, University of Virginia. So again, passive user here. Very interested in maintaining passive use and access to the universe. I think we all love the universe. Yes, like nods of heads on that. Can you say more or really anything about what active users are doing to maximize the efficiency of the frequencies that you do have access to?

[01:01:55.59] Because I hear over and over again, we need more frequency. We need more frequency. We need more frequency. Message received loud and clear knowing that every time you get that frequency, it takes away a window to the universe. So what are we doing to make sure we're using that frequency as effectively and efficiently as possible?

[01:02:14.48] THOMAS DOMBROWSKY: Yeah. So every generation of the mobile standard has gone from 3x to 5x more efficient use of the spectrum, number one. Number two, we do a lot of reuse of the spectrum. So back in the day when I started doing this years ago, we have 10 to 15 mile radius boomer satellite base stations that were covering the populous.

[01:02:35.45] We're now down to hundreds of feet if not distributed antenna systems indoor. So what we were trying to do is reuse those same spectrum bands over and over again more and more tightly. When I first started doing this, we would split it up by frequency or by time then we added in codes.

[01:02:51.05] Now we're actually getting it down to what we call a physical resource block, and we're prioritizing each of those little blocks of spectrum to reuse it again and again. The last thing is a mobile company wants to do is to have to go to another auction and buy more spectrum if they can avoid it, if there's a better way to do it. So we're constantly driving the standards, driving the vendors to actually use the spectrum more efficiently. And that's what I can say about the terrestrial at least.

[01:03:14.43] KIMBERLY BAUM: And then from the satellite perspective, as I had mentioned, I think we need to take a close look at how some orbit locations are being used. If they're not being used, then they should be opened up for someone who will actually use

them in existing frequency bands instead of having to look for higher or different bands. So I think we are looking at ways to be sure the spectrum really is used before we look for more.

[01:03:42.42] RICH LEE: I'll make a plug for the wind forum. They've just opened standards development and what's called highly dynamic shared spectrum. Michael and others participate in that. And I think that's going to be, to answer your question, how we are going to concentrate more use and reduce the pressure in just taking up more megahertz or gigahertz up the band.

[01:04:13.09] JULIE KEARNEY: Yeah. I think we're up. But I want to ask-- I see Michael Calabrese. Can we have one more question? If it's a really quick one, Brad? Dale, thank you for the save. Mother, may we? The gentleman in the white shirt.

[01:04:31.91] THOMAS DOMBROWSKY: Raise your hand, Michael.

[01:04:32.53] JULIE KEARNEY: Raise your hand, Michael. [LAUGHS]

[01:04:36.31] AUIDENCE: Yeah, I hope it will be quick because I'm trying to--

[01:04:38.77] JULIE KEARNEY: Make it quick.

[01:04:39.33] AUIDENCE: --build on what you just said is that so IMT, that terrestrial mobile has incentives, has change of faster change over in technology going up the G's. Kim mentioned that some of the old satellites in orbit may not be using the spectrum capacity.

[01:05:01.22] And then technology is developing. So with spot beams and software defined upgrades and so on, we can use satellite spectrum much more efficiently. So the question is, how should the FCC think about either sunsetting protections, for example, or requiring as part of the original authorization or modification some level of having the latest coexistence technology. Should they even be thinking about that or should they just say, no, it's anything goes?

[01:05:39.32] THOMAS DOMBROWSKY: Yeah, I mean, I'll go first. I mean, I totally agree with that hypothesis there. I mean, I think there needs to be some impetus to push folks to continue to innovate. And especially in spectrum bands that are not subject to auctions for their licenses, because there's not that sort of financial imperative to recoup the money that you spent to buy the license.

[01:06:00.69] So any way that they can force that would be a good thing from my perspective. And finding ways to relook at satellite licensing, writ large. I think to Kim's point, you've got satellite slots that are camped on by people or using systems that don't really have deliverable payloads. I mean, that doesn't seem like the right answer.

[01:06:23.25] I don't have the answer to the question as to how you get there, but I'm more than happy to have a discussion about it. I think it's

something that's very important and vital to have. And I'll just add the last thing is from my perspective as a guy who does terrestrial more than satellite, it's utterly frustrating that you cannot figure out how satellites operate by reading the FCC rules. You cannot.

[01:06:44.52] You have to go and read the 17 orders for every particular satellite system. And I think that would be another way to be nice to sort of--

[01:06:51.16] JULIE KEARNEY: Transparency initiative.

[01:06:51.83] THOMAS DOMBROWSKY: --revisit it. Yes.

[01:06:52.91] JULIE KEARNEY: Transparency initiative. Go check out the website. But I think there is a balance between having rules reflect the innovation that has happened, but also respecting the innovation that has been built to the rules. So it is a balance. And I think it is the responsibility of all of us, stakeholders, advocates, regulators to find a balance that works for everybody.

[01:07:18.03] And I do feel like the more we talk and have open fora like this and regulatory processes, I think we'll continue to innovate and improve. So thank you for that last question.

[01:07:30.92] PETER TENHULA: And with that--

[01:07:32.01] JULIE KEARNEY: Yes, thank you.

[01:07:32.57] PETER TENHULA: With that final remark, I want to-- we're going to now break. But before we do, let's please thank our wonderful kickoff panel.

[01:07:44.04] [APPLAUSE]

Panel: Sustaining Orbital Space as a Resource

https://youtu.be/TF3AsDT32Xk?si=nUNGuHOeDMbD3knq

[00:00:00.33] KEITH GREMBAN: Welcome to our next session. This panel is on Sustaining Orbital Space As A Resource. Commissioner Gomez talked a little bit about some of the issues here. I want to give just a quick introduction of some of the issues, and then introduce the panel and move into the questions. So as Brad stated earlier, space may be infinite, but near Earth space is getting crowded. As of last year, last April, there were on the order of 12,500 satellites in orbit and over 3,000 of these were inactive.

[00:00:38.75] So right now, 2,800 satellites were launched in 2023 and about 200 a year become inactive. So the numbers are working to make space ever more crowded. And I looked up a couple of other little factoids. And at this point in time, there's 128 million pieces of debris and satellites that are in orbit right now with a combined weight of over 10,000 tons. So can we sustain this as a resource?

[00:01:14.49] So we've got a very incredible panel here, I think, to discuss some of these issues. So immediately to my left is Jilian Quigley. She's an associate at Wiley Law, and is a space lawyer. She's co-chair of The Space and Global Communications Committee at the Federal Communications Bar Association. Next is Milo Medin. He's the founder of Logos Space Services, which is building a new dual-use low-Earth orbit satellite constellation.

[00:01:43.10] Next is Jonathan Skinner-Thompson who is an expert in environmental law, which is-- it's an interesting analogy to bring to our space resource issue. And at the end of the table is Angel Abbud-Madrid who is the Director of the Space Resources Program at Colorado School of Mines. So let's give a hand for the panel. [APPLAUSE]

[00:02:05.12]

[00:02:07.86] And let's get started. So I cited some figures about how crowded space is getting. And so my initial question is, is there a limit to the carrying capacity of near-earth space? Is there a practical limit to the number of satellites we can get up there at the same time. And if so, what kind of regulations are needed to deal with this issue? Yes I'd like to start with Milo, actually, since you're launching.

[00:02:33.60] MILO MEDIN: Well, it's a couple of years before we launch, but I remember this conversation I had with General Paul Selva, who was the Vice Chair of the Joint Chiefs of Staff. He was a air mobility command pilot. He was a C-17 pilot. And he was telling me the story about transatlantic air traffic control, because originally after World War 2, you had airlines starting to fly across the Atlantic, and they had very high spacing between them. And the reason for that was they didn't have comms.

[00:03:11.61] And then you had HF radios and you had oceanic control, and that allowed you to pack more and more together. And one of the points he made was now with GPS and with highly reliable satellite communications, you can actually-- the amount of air traffic going across the Atlantic is a huge multiple of what it once was. And I think there's a lesson there for space as well. That is, to the extent that we have knowledge of where objects are and more precision and can predict trajectories which the lower you go, the harder it is to actually predict, your drag-line gets higher. And so it's a little harder to figure out where things are going to be.

[00:03:57.70] But I think, if we have better space situational awareness and the ability to understand where things are with high degree of precision, that should allow us to actually be able to fit more things in. Altitude is driven by mission primarily. So, you might want to spread things out, but there are certain altitudes where instruments, radiometers et cetera, and comms work best. So I think part of what we have to do is think through the issues of how do we get better precision on where things are so that we can avoid them.

[00:04:38.59] And also the dynamics of how do we actually make that information available so people can take action and plan accordingly? There's a big transition going on between the Department of Defense to the Office of Space Commerce. The others could probably talk about that. It's probably going to be a slow transition, but I think the reason for that is to make Civil space navigation much easier to plan and deal with.

[00:05:08.51] JILLIAN QUIGLEY: Well, thank you.

[00:05:10.01] KEITH GREMBAN: Jillian do you want to take it--

[00:05:11.06] JILLIAN QUIGLEY: Yeah no. And I definitely agree. And I think OSC is doing a great job at building tracks, which is what they're calling their space domain awareness program. They're essentially trying to tell everybody where everything else is. And I want to add a little sci-fi element to this, just because that's one of my favorite things. Not only are we thinking about things that are currently orbiting that we have to avoid, but in the future when we're going out of orbits, we also have to think about how are we managing that kind of traffic when there is also traffic that's going across.

[00:05:49.62] And I think it's interesting when we try to look at other international frameworks. This seems unique to space, in that we don't really have the same issues with air space or with international law of the sea, where there are things that are autonomously moving in an orbit, and there are also things that are moving through orbits. And so we do sometimes encounter this for example, geostationary satellites. We do need to go through Leo to get to geostationary orbits. And so I think that in the coming years, it's going to be important to really think about how we're shaping regulations to ensure that we still have

pathways to get through Leo and to get through the outer orbits to get to the moon and to get to Mars, to get to pretty much anywhere else.

[00:06:40.17] KEITH GREMBAN: Jonathan.

[00:06:40.70] JONATHAN SKINNER-THOMPSON: Yeah. No. Thanks for having me. As mentioned, I'm an environmental lawyer. I've thought about these issues in the context of pollution control, and I wanted to share a little bit from the 1960s, when environmental issues were at the forefront of our political thinking and socially speaking. And there was this group called resources for the future, which some of you might be familiar with. They're an environmental economics think tank. And they put out a report called New Resources For The Urban Age.

[00:07:13.23] And what they were trying to do was think about how should we approach the pollution issue? Air quality, water quality. But they also listed Spectrum as one of the new resources of this age. And they said, or concluded that we need to start thinking about air quality, water quality as a congestion issue, which sounds similar to what the issue is here with space, that it's getting too crowded. And if we think about it as a quality issue, a congestion issue, rather than a supply issue, because space is infinite, air is infinite. The air that we breathe, for instance.

[00:07:52.17] But it's getting dirtier. It's not as usable because of congestion. And one of the approaches to dealing with congestion is we need management. We need to better understand the resource. We need to have experts who can monitor better, who can track all of the satellites that are in space. And so there are different ways to come out on the management side, whether we want to leave it to private ordering, whether there should be some supranational agency, whether nation states should do it.

[00:08:20.79] But I think there are a lot of similarities that we can-- or lessons we could learn, potentially from how environmentalists have approached somewhat similar issues. And we can talk about that a little bit more differently. But it's not all potentially that new.

[00:08:36.47] KEITH GREMBAN: Angel, any thoughts on this issue?

[00:08:38.82] ANGEL ABBUD-MADRID: Actually, in terms of how many satellites you can put out there in capacity, I think my colleagues can answer that much better. I focus on space as a resource, and in fact, it was the very first resource that we utilized from space. If you look at Telstar 1 in 1962, it was the first time that we realized that space could have a value to have an application. That's when the whole communication satellites revolution started. So we see it as an asset. But obviously increasingly we're seeing this also as an issue. So I worry more about what to do when these things get more crowded and how we can utilize this as a resource later. So I'll probably comment more on that aspect.

[00:09:23.14] KEITH GREMBAN: OK thank you. So you mentioned some interesting things about watching orbits better and trajectories and so on. But how do you regulate this and enforce it? Is there an international authority? How do we get nations to cooperate on this? So I'll toss that to Jillian first.

[00:09:45.13] JILLIAN QUIGLEY: Yeah. So there's a couple different international frameworks. So in terms of managing orbits and managing Spectrum rights, there's the ITU and they do a large amount of just Spectrum and that also includes orbits because those are intrinsically tied. And then you have UNOOSA who helps with the space object registration pursuant to the registration convention. And then in terms of liability for this kind of space debris, how do we keep actors from doing bad things? We have the liability convention which is tied into the registration convention and the other international legal frameworks for space.

[00:10:26.85] But on more basic level, in addition to those, we have-- it's a double-edged sword, because when actors do bad things in space, it often does have blowback on them as well. And so one of the examples is the Russian ASAT tests a couple years ago created.

[00:10:45.97] KEITH GREMBAN: Acronym.

[00:10:47.13] JILLIAN QUIGLEY: Oh my goodness. It's anti-satellite test, is ASAT. Yeah, and so they essentially shot a missile into space and blew something up in space. Generally, the International community does not look fondly on ASATs just because it creates a lot of space debris. Yeah it's very bad. Very bad. We don't want it. And so the ISS recently has had to do a lot of evasive maneuvers because of this new space debris that was created. Incidentally a lot of Russian nationals are on the ISS quite often. And so a lot of the time, it disincentivizes actors to do things because they often have to deal with the consequences just like everybody else.

[00:11:34.90] MILO MEDIN: Yeah, I think that's exactly right. Especially if you think about operators like SpaceX, like us, like others who are putting multiple satellites in plane. If one of your SATs dies, you're the one who's the most likely to suffer as that orbit begins to degrade and it's more likely to bump into you. Now, if you've got a dozen SATs, all in different inclinations, well, you're probably not going to run into yourself. So it's a different dynamic there. But I think for the folks who are building these constellations, we're the ones who are really focused on making sure we don't mess up our own orbits.

[00:12:22.96] KEITH GREMBAN: OK. And I've got to go to Jonathan next, because this international resource collaboration just seems like the analogies to environment is--

[00:12:32.08] JONATHAN SKINNER-THOMPSON: No, absolutely. And so I might, before getting into that, take a step back just to provide two different contexts in which we might address this issue. There's the

international sphere of courses. How do you get the nation states to coordinate with each other and the private actors. Because international law tends not to directly address private actors, they have to go through governments. And then there's also the domestic legislation or the domestic regulation, that's where you often see most of the international requirements being implemented. Or we see some more of the bite on private actors is how do those national governments regulate these individuals or these parties?

[00:13:14.07] And I think there are issues with both. The International side is how do you get the nation states to cooperate? Who are the big players? Is it really just a handful of countries that are launching satellites into space, and so really just need those countries to work together to agree? How do you get Russia and the United States and China to agree currently on the use of these resources? There might be some analogs to that. The polar. The Arctic, for example, is an area where you have these major players constantly butting heads with one another, trying to claim more of the polar resource. So that seems like an appropriate analog.

[00:13:58.04] But then domestically, how should we design a scheme, a regulatory scheme that best addresses the problems that we have with space, and the problems might be too multifaceted. It seems to me, and I'm not an expert here, but there's the spectrum issue, which is congested lines, and then there's the debris issue. And those might be addressed differently, because one looks more like a toll road situation, I think. And the other one more, the quality of the area. It's getting congested with space debris. That seems more like a traditional environmental problem.

[00:14:33.69] And under domestic US environmental law, we've dealt with those types of problems in different ways. One and maybe we'll get into this a little bit more and I can jump into that. But one approach is to think of it as we do with the air. We set objectives, a goal, a quality objective and say, this is how much debris we're willing to tolerate. And then we'll regulate down from there. Who has access to it? Who gets to put in a new satellite? What are your obligations for your expired satellites or shuttered satellites, the ones that have run out of gas, et cetera?

[00:15:08.48] So we can come up with different regulatory regimes to address those problems. And there are different incentives that come into play. And I can jump into that a little bit more later as well. But I think one of the big questions is, do we want to focus first internationally, domestically, and how do they relate to one another. And there are a couple of international regimes. The law of the sea is a great example, as one where we can borrow a lot of that history.

[00:15:33.86] KEITH GREMBAN: So you want to jump on that international issue?

[00:15:36.03] JILLIAN QUIGLEY: Yeah.

[00:15:37.91] KEITH GREMBAN: You talked little bit about that earlier.

[00:15:39.01] JILLIAN QUIGLEY: I think there is a link between the domestic regulatory regimes and the international legal frameworks, and some of it does have to do with using the states as the main legal channel for some of these issues. And so all of the operators who are launching in the United States, although the United States doesn't always claim itself as a launch state, they often say like, we're registering this, but it's not ours.

[00:16:06.93] So the launch state concept is really important at liability. And so oftentimes what happens is the state that is responsible for causing damage or causing debris is the one who's held liable. And then that gets passed on to the operators. And so there is a channel where we can use it. And I think that the Law of the Sea is a really good example of that. It's also used for flag states. In the Law of the Sea, if there's pollution or if there's other damage, it's passed on to the state, and then it gets passed on to the operators.

[00:16:41.88] ANGEL ABBUD-MADRID: Yeah this is quite an interesting topic because you can then expand it to what was going to happen a little bit more into the future. You alluded to that a little bit about what happens when you start going beyond LEO and GEO orbits. Right now, the United Nations Office of Outer Space Affairs, UNOOSA, is now considering-- it has a subcommittee on space resources. And it's going just beyond space as a location resources. Now it's looking at, energy and solar and lunar resources and the like. And just a couple of months ago they got together to discuss these type of things, what to do.

[00:17:19.26] If you're worried about debris now, think about what's going to happen once you start trashing the moon with all sorts of landers that are crashing these days. This is going to be an issue. And how do we go beyond the way that we've been handling enforcement these days, which has been-- practically, what happens at the United Nations is name and shame. Somebody did something wrong and you point fingers and somehow the situation is solved. But as we keep going further out into more exploration, moon, Mars and beyond, this is going to get a little bit more complex.

[00:17:50.93] And now you have not just space agencies, you've got private actors. And you're right, you have to go through your country. But how do you establish the rules of how to behave in space. It's going to become increasingly important.

[00:18:04.69] JILLIAN QUIGLEY: To emphasize this, I do think that there is a really important role that the industries have to play, and I do think that there needs to be more diversity of entities involved at the international level, because ultimately, at the of the day, the industries are the ones who are making these changes, and they're the movers

and shakers of these technologies. And so to some extent, even though the governments might be responsible for being the main liability channel, I think that there needs to be a lot more ability for the industry to be able to participate in a lot of the norm building and the regulations, both domestically and at the international levels.

[00:18:43.67] ANGEL ABBUD-MADRID: Which you can't at this point because it's just countries getting together. They do listen to some comments, but industry and the private sector is not actively involved.

[00:18:55.75] JONATHAN SKINNER-THOMPSON: And I'll just jump in on that point. In the environmental context we've had similar issues again and different outcomes. So looking back at on the stratospheric ozone hole or the ozone hole, industry was a major player in negotiating those treaties and those agreements. Absent industry support for the ozone depleting substances bans, I don't think those treaties would have gone through. So that's an example historically, where we've seen a very successful treaty outcome because industry was willing to play and because countries were listening to them.

[00:19:36.74] We've also had multiple examples on the other side where with climate and with the plastics negotiations currently, or trying to negotiate a global plastics treaty, there have been big critiques that industry has prevented any type of international agreement on that side. So knowing how industry fits in obviously key players, but how they fit into the negotiations can lead to different outcomes too.

[00:20:05.11] KEITH GREMBAN: So what are the forums for negotiating these regulations? What are the organizations that we have to work with? It's kind of a question out of the blue here that you just made me think of this for time. The ITU is one, but they're mostly doing spectrum. There's no similar organization to the EPA internationally for space, though.

[00:20:32.63] MILO MEDIN: No and I think international relationships are not in the best place that they've been in a while. So I think the question is really about maybe, rather than treaties, at least having actors set norms is something that you can do without necessarily having formal international relationships. And I think that may be the path forward for the folks who are the most active in this area and have investment that they want to protect.

[00:21:11.15] JILLIAN QUIGLEY: And to add on to that, International Law has a few different layers. One of the primary layers, because treaties are incredibly difficult to negotiate, is what's called customary international law. And that is this type of law that exists, that parties follow and that states follow, that is developed out of custom and out of norms that we've built. And so just because there aren't treaties in place or treaty bodies that handle these issues internationally, doesn't mean that there isn't-- there are rules of the road. And so just because

it's not written down on paper, that doesn't necessarily mean it doesn't exist in practice.

[00:21:52.94] JONATHAN SKINNER-THOMPSON: I think the UN Law of the Sea actually, is a good example where-- assuming there is some framework treaty that gets put into place, maybe for space in building that treaty, you can incorporate at least the way the Law of the Sea works is generally recognized international rules and standards, which can come from other agreements that aren't necessarily treaties. And so it's like allowing or creating a way to incorporate customs, practices of the community of industry, of other nation states without having to put it into the treaty, because as was mentioned, it's hard to negotiate a treaty and the language of the treaty.

[00:22:31.01] But there are ways to build a treaty that allow you to incorporate some of those future developments, especially in an area like space where technology is evolving very rapidly, and it's going to take too long to come up with a treaty that's going to be able to address every single new development. So if that's the approach that's taken where some framework treaty is developed, it might be useful to have those outlets.

[00:23:00.43] KEITH GREMBAN: So we talked about debris a little bit. And Angel brought up the issue of littering on planetary bodies and so on. There's also an issue of littering in space. A satellite has a finite lifetime. It's only got so much fuel and so on. What do we do with used satellites? Do we leave them at the side of the road like a car?

[00:23:24.70] MILO MEDIN: I think it's not just the satellite itself. You've got parts from launchers. Not everybody has reliable launch like SpaceX. Let's leave it at that. There have been boosters that have shed parts all over the place in relatively high altitudes. You've got the deployment mechanisms. There's a lot of care now being put into place so that we don't have little parts when a satellite is ejected from the vehicle. Those little parts are hard to track. Arguably they're worse than satellites to deal with.

[00:24:04.75] So how you do the mechanical design of the launcher, any bus integration or spacecraft so that when things are being deployed, you don't have pieces that are left? And that's really intentional work that has to go on. And I think the US has done a pretty good job in working in that area. With regards to satellites, I think, as I said, if you've got dead SATs in your orbit, that's a problem for you.

[00:24:41.95] For us, I think we'll do the same thing that SpaceX does, which is do insertion at a lower altitude, turn everything on and then climbed to the target altitude with electric propulsion, with EP. So if you've got something that dies and it's early failures, you can then reenter or it'll eventually come down without many, many years. And so if you can get the early failures taken care of that's a good thing.

[00:25:16.85] But even for GEO parking orbit, you're putting things in there that are going to be there for a very long time. Right now that's not a problem, but over time, you could imagine those orbits potentially becoming more usable. So this is a problem we all have to deal with.

[00:25:37.06] JILLIAN QUIGLEY: I brought some fun facts about space debris like you mentioned. There's a lot of space debris. And it's not only satellites. Between 1 and 10 centimeters, there's about 500,000 fragments in orbit. 10 or more centimeters, about 34,000. Under 1 centimeter, 128 million pieces. And you can't track them. And so if a 1 centimeter, 10 gram piece of debris hits something, it has about the same amount of explosive force as a hand grenade. And so--

[00:26:08.62] MILO MEDIN: 1/2 MV squared.

[00:26:10.28] JILLIAN QUIGLEY: Yeah. It's a teeny tiny piece of debris that we can't track, that's going to be hitting something. And often that's incredibly hazardous. And so that should also be factored in addition to satellites. There are a lot of companies right now that are doing some really exciting things. So some companies under what the FCC is calling ISAM, which is in service manufacturing and-- In-space Servicing and manufacturing?

[00:26:44.29] So they have various types of bodies. So there's a spacecraft that will go around and collect debris. There are a couple companies that are testing out refueling mechanisms. And using tiny nozzles on the satellites to put more fuel in so that we can extend the lives of those satellites. Because one of the things that we need is fuel. And that's often a mission limitation, especially for geostationary satellites.

[00:27:12.55] And then there's other types of mission extension vehicles that once the satellite is almost defunct, they can move them, I call them tugboats.

[00:27:21.47] MILO MEDIN: Almost.

[00:27:22.80] JILLIAN QUIGLEY: So there's a lot of really exciting things that are happening right now as we speak, that are about to be launched or that have just recently been launched that are helping to remediate some of these issues. But at the same time, we can always do more. The FCC is doing a great job at helping that happen, but there are a lot of really difficult aspects of it, especially because of orbits and because of spectrum rights that we can't always use-- we can't always innovate in the way that would be best.

[00:27:56.27] And so more flexible regulatory schemes are always something that would be welcome for this.

[00:28:02.94] ANGEL ABBUD-MADRID: And I think that we can talk about remediation later, but I think you touched on a very important point. How do you at least mitigate and what is happening right now

on refueling is a very important part. We have a company right here in Colorado, Orbit Fab, that is trying to do that even has a contract with the US government on how to start refueling spacecraft.

[00:28:24.99] And this is important not just for companies, but also the military is quite important according to their maneuver without regret philosophy that they have. This is a way for them to be able to move satellites and move quite rapidly. And that can also mitigate the effect of space debris. And as we speak, there's a Chinese spacecraft that is testing refueling in space. It was launched last week.

[00:28:52.26] So this creates also geopolitical tensions that people are advancing very rapidly and see how they can refuel in space and in a way, in a secondary effect, could mitigate some of these aspects of space debris.

[00:29:10.44] JONATHAN SKINNER-THOMPSON: So one of the issues that we've had in with land pollution is with orphan. Sorry one of the issues we've seen with land pollution is orphan wells, abandoned oil and gas wells, or slag piles from abandoned coal mining operations. The liability for cleaning up those sites often falls to the state, in this case, the state governments. And there's potentially an analog here with space. The liability is falling on nation states. If you have maybe a defunct company that's no longer around to pay for the cleanup.

[00:29:49.45] And there are a couple of different ways state governments have tried to approach this issue. One is that new operators, new oil and gas, new coal mining or any mining really, they put in financial assurances or insurance requirements so that if those companies go defunct, the bill doesn't fall on the government. And so that could be something to consider here, where you have new operators launching into space, and maybe they would at least put up some money so that the National government isn't ultimately responsible for it in the end.

[00:30:23.56] But then you can also incentivize recycling. Pennsylvania did this with its abandoned coal waste piles. They actually created an incentive scheme that allowed companies to burn used coal waste. They didn't have to meet the same regulatory requirements, the same air pollution controls as other coal fired power plants. And so there were some environmental costs to it, but it at least incentivized the use of these abandoned coal piles.

[00:30:56.29] And so there may be a way to incentivize companies to go up into space and start collecting some of these abandoned satellites or debris by lifting some regulatory requirements or providing a financial incentive. And then the other regulatory scheme that I might throw out there for consideration is what we call the Resource Conservation Recovery Act. That's a cradle to grave permitting scheme that includes permitting requirements for the use of hazardous substances, chemicals, toxic substances. And it says if you're

going to create it, if you're going to use it, these are the requirements you have to comply with. And here are the closure requirements before you can dispose of it.

[00:31:40.07] So maybe there are satellite design, cradle to grave type of requirements that could apply to anybody who wants to launch a satellite into space that if you're going to do it, this is how you have to design it. This is what you have to do when you want to shut down your operations, et cetera. So there are a couple of different ways to approach this issue too, I think.

[00:32:02.13] ANGEL ABBUD-MADRID: And since you brought up recycling, I think that that's a-- this is a dark, gloomy picture that is painted about debris. You can actually have a potential opportunity on recycling this material, just like we do, at least in my home every Friday, every two weeks, that you throw things in the trash can and it gets recycled and that's an-- a trash could be an opportunity for somebody else. And this is happening right now. How do you go from trash to treasure? Somebody else's trash could be actually a treasure.

[00:32:34.40] So imagine this scenario. You have company A that-- and this is a private sector doing this, that is able to pick up some of the debris that has a problem and spend rocket or satellite, then sells it to another company that removes some of the important pieces, but also cuts it and makes it available. And a Space Station. Could be the Space Station right now, the artificial one. Then sells it to another company that can actually melt this, or a foundry that can turn it into a could be a structure in space like ISAM space manufacturing or a propellant.

[00:33:15.86] And this is not far fetched. This is happening right now. There's a company, A, Astroscale, that picks up your debris, and these are part of their plans, and they will pick up some of the pieces, probably larger ones. Then goes to another company called nano-racks that is doing this in the Space Station. And it's cutting this material. Goes to a company called CisLunar industries, which is here in Colorado that produces a little pellet.

[00:33:43.10] This is solid propellant that can be used for electric propulsion so that another company, Newman Space from Australia, can use it and actually has proven to use this as a propellant that can then be used by the same Astroscale spacecraft to continue picking up the debris. So this is an opportunity to convert trash to treasure and in fact, debris to delta-v and one thing. And so these are opportunities that we should not-- obviously, there's economic issues. This is possible. There are legal aspects. Can you actually get a hold of material that belongs to another company or country?

[00:34:20.73] But we should be aware of this type of opportunities where companies can collaborate to solve a problem that is affecting all of us.

[00:34:32.86] JILLIAN QUIGLEY: And then so one of the wrinkles I love this idea, one of the wrinkles that I feel like we do have to address is the fact that space debris and all space objects belong to whoever launches it or to the operator. And so it is the property of the operator, even if it's a centimeter of space debris. And so I think that there needs to be some sort of regulatory mechanism whereby, when you're doing these types of recycling things where you can easily transfer the rights to it.

[00:35:04.61] But there's a lot of other things. So what happens if there's a tiny piece, once you've collected it, that gets sent away and then it causes damage to something else, who's responsible for that. Is it the operator or is it the person who's collecting the debris. And so I think that it's definitely something we need to start thinking about as this becomes more realistic.

[00:35:29.46] KEITH GREMBAN: So there actually is also another connection between space operations and environmental. Because if we burn satellites up to de-orbit them, that has environmental impacts, doesn't it.

[00:35:43.21] JONATHAN SKINNER-THOMPSON: Absolutely. And there are principles in place for the trans-boundary impacts of pollution. So if we think of debris as pollution when it burns up in space, there's the default norm in international law, which is that countries sovereigns can use their resources freely up to the point of impacting, harming another country. So you can't cause trans-boundary harm. But this principle is pretty weak, generally speaking.

[00:36:13.72] Usually, it's a due diligence principle. It's that you've taken some steps to address it. If you do nothing, if you have no domestic laws in place to address trans-boundary pollution, then you're probably responsible under international law. But if you have some rules in place, the point of that being that not all countries are going to have the same level of development in terms of their legal systems.

[00:36:36.01] And so you don't want to create a requirement that every country, for example, have a Clean Air Act that is as sophisticated as our Clean Air Act. And so you allow for some of those differentiation among the nation states. So there are some principles at play, but often the international norms aren't as strong as one might want them to deal with these types of harms.

[00:37:02.04] KEITH GREMBAN: Anybody else have some thoughts on that? So one of the things we talked about a week or so ago was along the lines of your debris to delta V, but was recycling parts as whole pieces and using them in construction of new facilities up in space, is that a going concern yet or?

[00:37:27.61] ANGEL ABBUD-MADRID: No, definitely. That's something that is being considered. And like I mentioned, this could

be propellant, could be structures in space. But you have to also do a trace study with this. Compared to sending a rocket to remove this, can you actually do it in space. It has legal implications like Jillian mentioned. But definitely this is being considered because debris is a resource. If you look at it from that point of view. Instead of burning it in the atmosphere after spending thousands and thousands of dollars per kilogram to send it, why not recycle this material and obtain the titanium and the aluminum and the chromium and everything else.

[00:38:07.10] Solar panels, I think Milo can even speak to this, without having to go through all the process you can probably recycle this. Maybe you can add to that.

[00:38:16.50] MILO MEDIN: Well, I don't think-- rather than trying to reach into the entrails of a bus and pull the particular thing that you want out, at least the panels are external. That being said, solar panels do age out because of radiation. But I think, if you're going to get parts, the panels would be the pieces that are the most naturally exposed. And potentially maybe you could think about more or less standard mounting and detachable hardware, that those parts could be detached separately and potentially recycled.

[00:38:58.89] It's an interesting question. And I think the question ultimately boils down to the economics. Because economics is always has the second to the last vote. Physics has the last vote, by the way, but economics has the second to last vote.

[00:39:17.27] ANGEL ABBUD-MADRID: Good point.

[00:39:21.96] KEITH GREMBAN: OK. No more. So I want to come back to the issue of debris again that seems to stick in my mind as one of the key issues because I read articles about what you said, the ISS having to move and so on. We've lost track of who caused what debris. We can recycle satellites, are there technical methods now that we're getting to where we can begin to deal with the debris better?

[00:40:00.79] MILO MEDIN: I think the question is really about, do you know where it is? And therefore you want to avoid it. Because if you don't avoid it, you'll generate more debris. That's the worst problem, I think. A lot of the older satellites may be less valuable. It's just not as much interesting things about them that might be recyclable. And so I think one of the interesting questions I have is, I'll just be interesting as any one here from CU would be willing to do a study like this would be, has our debris generation materially improved per launch over the last 20, 30 years?

[00:40:46.02] I suspect the answer to that question is an overwhelming yes, but I don't have the data to back it up because in the old days, people didn't worry so much about bolts and umbilicals and stuff like that that came off. I think everybody who is working in consultations now is very attuned to the debris issue. And so is this problem getting

better just because of normal incentives. And I think that's an important thing.

[00:41:16.76] Again, we're blessed by a lot of great launch companies. And SpaceX has done a bunch of work in terms of debris mitigation in their launchers. I'm not sure Long March and those are in the same place. And then the question is if the Chinese are going to launch their own very large constellation using a bunch of boosters that might not be so good with regards to debris management. Where's the international forum to work.

[00:41:54.10] KEITH GREMBAN: What are the regulations? And who's the enforcer for some of this? Are there any thoughts on that?

[00:42:01.90] JILLIAN QUIGLEY: I personally would really like to see an Unclosed-type treaty for space. Unclosed provides a lot of bodies that a lot of these issues are hashed out. For example, like the IMO, the International Maritime Organization. They do a lot of this international work and interestingly, the IMO is actually really great because they also incorporate industry. And so industry representatives are also very active.

[00:42:29.85] And so I think that we can use existing international law as an example or as a really good primer for how we want to be doing these things in the future.

[00:42:43.64] KEITH GREMBAN: So we ever going to hit the point that we need orbital Superfund sites?

[00:42:49.00] [LAUGHTER]

[00:42:52.84] MILO MEDIN: Again, if you think the problem is getting better over time, then as the old stuff eventually burns up. Maybe net, net this problem will, I won't say solve itself, but it will get better. On the flip side, if you've got assets going on and collisions that could generate more debris, those are events that can materially change that, the quality of how clear space is. And those are things that we have to be very focused on.

[00:43:29.22] JONATHAN SKINNER-THOMPSON: I'm sure creating an International Super space Superfund would be interesting. But one of the interesting things about Superfund, I think this is our US cleanup law. It puts all of the liability on the current owners operators. So maybe the owner operators here would have to think whether they're the nation states or whether it's the companies. But one of the advantages of Superfund, I think, is that because it's a strict liability statute, it doesn't care about fault. It shifts the obligation or the hashing out of who pays what to whom back to the private actors.

[00:44:08.20] So you have a current owner of a contaminated site. The liability is on them, and they have to clean it up and pay for it. But if they can find the responsible parties, go back through and do their own diligence, they can make them pay. And so there's an incentive on

those current owner operators to start doing all of the hard work of figuring out where did this piece of satellite, who owns this piece of satellite that caused the damage here to my satellite. And so you can force the private actors to work it out without the governments having to be involved in a way.

[00:44:43.48] So there might be some. I wouldn't say it's a perfect analog to space, because of the ownership issue, but it does create some interesting incentives for-- and efficiencies, I would say, if you create a strict liability type of regime in space.

[00:45:01.33] KEITH GREMBAN: Any other thoughts on that one? I want to circle back to our original question about the carrying capacity and monitoring orbits and so on. Should there be an international organization that coordinates that? All right. Now, you mentioned department of defense in the US tracks space debris and they're moving that over to commerce. Is it possible for an international organization to do that? Should there be one or--

[00:45:32.26] MILO MEDIN: I think right now the US is the nation that's putting more things into orbit. So it has the incentive to make sure that we know what's where and how to avoid collisions. And I think it's always good to structure organizations so that incentives are aligned. I'm not sure if you want international ownership of that function buys you right now. But that going forward there's going to be more nations operating in space and putting things into space.

[00:46:12.02] And so at some point in time, it may make sense to look at that. But I think the capability and the incentives are well aligned right now for the US to lead that.

[00:46:23.98] KEITH GREMBAN: Are there any thoughts on that front or?

[00:46:26.58] JILLIAN QUIGLEY: I do think that-- so a lot of the US companies like what essentially happens is they provide what's called ephemeris data to, it used to be space defense squadron, I think eventually they'll move that to tracks. But the data is only as good as what you're giving it. And so I think that if we-- like in the United States, I think that we have a robust system for dealing with this and operators and the agencies involved are in sync and they're working in step together.

[00:46:58.88] I think it gets a little bit more difficult when you have other countries who have operators who don't necessarily have to abide by those and so that ephemeris data, or if they're even providing it is not as good. And then there's a lot of interesting IP issues associated with ephemeris data. And that's something that comes up sometimes, how detailed do we want to provide for this. And so I think it's an important discussion that we do need to have both about the IP and about sharing between countries and creating an inter-operable system.

[00:47:36.84] MILO MEDIN: I do think it's not generally known about how much we depend on self-reporting for ephemeris. And I think their national security consequences of that as well. And so I think having active surveillance in both in optical and with radar and other mechanisms to validate and to notice when things don't behave the way they're supposed to. There's an alignment there. From the National Security objective as well as the Space Traffic Control objective.

[00:48:18.82] JONATHAN SKINNER-THOMPSON: So I think this is where the analogy to at least international environmental law starts to break down, because with most international environmental law treaties, there's an exception for national security. Generally, however, the militaries aren't the primary polluting sources. In environmental law. So even though there's this exception for them, we're still addressing the problem. We don't have to worry about it.

[00:48:47.06] With space, I think it could potentially get a little bit more complicated and not quite as similar to the International environmental law context, especially when you have maybe some actors where the satellites that they put up or the services that they provide are quasi, private, quasi, military. So I don't mean to call out SpaceX, but if Starlink is in the sky, they obviously provide private internet capabilities, but they also support some military operations.

[00:49:19.23] Do they get an exception under International Space law for their operations because there are national security exceptions, or how do you fit that into the scheme that's developed? Because it might be very easy for some countries to just claim that everything is a national security issue, and so they don't want to be covered by whatever agreement that's come to. And so that could be too big of a hole that's created in these regimes. But I don't know how to deal with that.

[00:49:52.35] KEITH GREMBAN: Hey, we're just about out of time. Any closing thoughts from anybody on health.

[00:49:57.28] ANGEL ABBUD-MADRID: I would just leave you with one thought. If you think the problem with debris is hard here on Earth, how are we going to deal with debris and get rid of it? How things are getting so crowded. Try to look a little bit into the future and not so far out. You have the United States, you have Europe, you have China, India, Japan, all of them with plans to have a lunar base by the end of this decade or early next one.

[00:50:24.66] They're going to need infrastructure. They're going to need power and transport and communications. They're going to have to be able to communicate and pinpoint every location on the moon, on the equator, on the permanently shadowed regions, on the far side. And think about a place in which there's no atmosphere. So where does a lunar satellite goes to die. There's no way to return it. Where are

you going to put it. This is a place that according to the space-- the Outer Space Treaty, nobody owns the moon. So what are we going to do there when the time comes.

[00:50:57.52] So some food for thought, literally because we're going to talk this on Munch and Muse tomorrow, so stay tuned.

[00:51:04.37] MILO MEDIN: Maybe a lunar landfill is what's required.

[00:51:07.30] [LAUGHTER]

[00:51:11.14] KEITH GREMBAN: OK. So it's time to open up the questions, so for otherwise our first question goes to student.

[00:51:21.20] KAYLIE WATER: Hi. I'm Kaylie Water, recent graduate of Colorado Law. You mentioned that or space air traffic control. Who do you think is best situated to act as a space traffic controller up there?

[00:51:40.62] MILO MEDIN: Right now the function of collision avoidance is distributed. But most space operators want to make sure they don't bump into something. So the primary job is understanding where things are and keeping those things up to date, so that entities who fly the spacecraft can avoid bumping into things and causing collisions. So I think the emphasis right now is on space situational awareness.

[00:52:12.13] The question is, you probably don't need somebody to tell you to move if the data shows that you're going to run into a collision and you're going to have an incentive to move. So I think the focus is really, I think from my perspective on space situational awareness and not directing traffic. I don't know if--

[00:52:38.61] KEITH GREMBAN: Thoughts on that? OK. Open up to other questions and just remind everybody that when you get the microphone, state your name and your affiliation when you give the question. So we've got one right down here in front.

[00:52:57.24] BRIANNA: Thank you. [INAUDIBLE] NTIA. I have a international policy question. How do you make sure, since space is a resource for the whole planet and you guys are talking about, other countries are starting to launch, how do you make sure there's an equitable access to the space for all the 180 countries that are there, and you are not causing disasters like what you're talking about.

[00:53:23.93] And it's circling back to the environmental aspect, it reminds me of the CO2 pollution that industrial countries started pollute the air and then all the other countries started to do that. So how do you make sure that's not going to happen. Is there any mechanism in international places that make sure that's not going to happen?

[00:53:47.28] JONATHAN SKINNER-THOMPSON: Yeah, it's a great question. Sorry to jump in. Because we haven't addressed it

internationally for climate change. Interestingly so there are these phrases in international law that are often used to describe differently things. The seabed, for example, is referred to as the common heritage of humankind. That means everybody has access to it and has the right to share in its benefits. So if one country starts mining the seabed, they're legally obligated, arguably speaking, to share in the benefits with everybody. All countries have a right to that.

[00:54:22.82] There was a discussion, when negotiating our climate treaties whether to call the atmosphere a resource, a common heritage of humankind, meaning if the United States, England, many developed countries or industrialized countries, excuse me, have used the atmosphere as a carbon sink then they should share those benefits with all countries. Well, that request to add the common heritage of humankind language into the climate treaties was rejected. It's not considered a resource for purposes of sharing the benefits.

[00:54:58.83] So it didn't work for climate. Maybe space will be different. I suspect it won't be.

[00:55:08.05] KEITH GREMBAN: Another. Let me go to the back over on this side first, I'll get you next.

[00:55:15.43] GREG COPP: Greg Copp, University of Colorado LASP. Curious, when you come up with regulations for spacecraft--

[00:55:21.94] KEITH GREMBAN: LASP is?

[00:55:23.27] GREGG COPP: Laboratory for atmospheric and space physics.

[00:55:25.51] KEITH GREMBAN: Thank you.

[00:55:27.08] GREGG COPP: When you're regulating spacecraft, are you going to be differentiating between different classes of spacecraft. I'm interested particularly in CubeSats, things that are inexpensive, scientifically useful and can be completed on a student's career time frame, but they generally can be considered maybe as space debris because they have no way of moving out of the way of some collision or doing controlled reentry.

[00:55:56.00] So to keep them inexpensive, need to be treated differently from something much higher up and much bigger. So do you see differentiation between spacecraft classes and regulations applied to each of them?

[00:56:10.70] [INDISTINCT SPEECH]

[00:56:12.81] MILO MEDIN: You could start.

[00:56:14.07] JILLIAN QUIGLEY: OK. So there actually are. The FCC has done a really great job at creating what's called the smallsat procedures. So that's anything under I think, 180 kilograms with less than five years in orbit, it creates an expedited licensing process.

However, they do still have to provide what's called ODAR, which is Operational Debris Assessment Review, I think. Something like that, which is an extensive amount of math and all of these other things, and you have to show exactly how you think the satellite will demise, whether it's going to burn up, depending on how large the smallsats are.

[00:56:53.83] So they could be teeny tiny, they could be like the size of a skateboard, a little bit bigger. They will require various types of-- you need certain capabilities in order to not have to worry about other requirements. So one for example, you need to have propulsion in certain circumstances if it's a certain size. And so some of the smallsat procedures exempt the small satellites from doing that. And it's intended to ensure that these types of uses can actually occur.

[00:57:33.47] MILO MEDIN: Yeah I would just say a couple of things. The decline in the cost of access to orbit not only makes it easy to launch smaller sets, but also easier to launch bigger sets. And so I think the question about where payloads go. What's the evolution. We're starting to see a lot of bus providers making commercial buses, so that you may not have to actually go build your own satellite anymore.

[00:58:08.65] You could put your radiometer or sensor on a commercial bus that may have scale efficiencies, so that it has GNSS location and telemetry, so that you can report your position to the ground very accurately. Again, I keep going back to situational awareness as being a really important thing. And so I think there clearly are different rules for different classes, but as the cost to orbit keeps getting cheaper and cheaper, I think you're going to see a different mix of spacecraft.

[00:58:48.64] And I actually think, in some ways, constellations like ours could actually host scientific instruments. And you've got bandwidth, you've got power. And do you really have to build completely separate sets of spacecraft? If we start thinking about the buses that are being used in constellations as a platform. I think you could do some really interesting things.

[00:59:18.48] KEITH GREMBAN: Anyone else care to get that? OK. Next question. We've got somebody here has been very persistent about getting the hand up. I'm sorry Dan I missed you here. So right, middle row, middle of the row here.

[00:59:36.99] JESSICA HEIM: I'm Jessica Heim. University of Southern Queensland, but I'm based here in the US. Anyway, my question is about the space situational awareness and the orbital carrying capacity. A lot of times when I go to events, especially things that are industry focused, whenever somebody asks about what is the carrying capacity of space. And the answer always seems to be, well, we'll have better space situational awareness, we'll have better maneuvering

capacities, and that will increase the density that we can have in a given orbit.

[01:00:05.57] But then the question is, that sounds like a really good answer, assuming that you know where everything is and that you can maneuver everything. But there's so many satellites that cannot be maneuvered, let's say you have a hardware failure. And then, like Jillian was saying, just like the small pieces of debris that aren't trackable as potential to cause something to explode if it hits in it, things like that. And then add in the volatility of like geopolitical situations, things like that.

[01:00:30.65] So how do you arrive at trying to figure out what's a safe orbital carrying capacity in a given area. Given that you have all these wild cards that you can't predict that could radically alter a safe environment.

[01:00:46.10] MILO MEDIN: I'll try this. I'm not sure having a number is that useful. That is to say, the question of what's the theoretical max that you could have if you optimize all of these things is what do you do with that information. That is to say, I think one of the questions is anyone who's building things going into orbit, you have to deal with collision avoidance. You should be designing the bus, the spacecraft, the launcher to not release extra parts.

[01:01:25.15] The small debris that's in lower orbits will eventually burn up. And so the number of what is the max capacity, carrying capacity, changes as these things happen. So I'm more interested rather than what the number is, what the curve looks like. And so I think what can we do to increase that and what is naturally going on that increases that carrying capacity because of all the changes that are happening in the industry already.

[01:01:58.74] So from a policy perspective, I know oftentimes in Spectrum people want like in broadband. What's the number that should be considered broadband? How fast is broadband? In reality, that definition changes over time as different applications, different user classes come in to the network. And so what you really want is to understand what that curve looks like and not just one point. So I don't know if that's useful or not.

[01:02:38.28] JILLIAN QUIGLEY: I am so excited I get to bring up my favorite topic right now, which is Zombie Stats. We had an incident a while back where a satellite got hit by a solar flare and stopped responding to hails, and so we couldn't-- the operator couldn't conduct any TT&C that's Tracking Telemetry and Command. And so it was just moving around in geostationary orbit, going into other people's orbital slots along the geostationary arc.

[01:03:10.62] And so it's what you're thinking about. The really remarkable thing about it is that there was so much cooperation between different countries, between different operators. At one point,

the satellite actually went underneath another satellite and blocked their beams. And so what they ended up having to do was the satellite operator who was above actually used the other satellite to transmit all of the stuff that they were doing while it was moving through their orbital slot.

[01:03:41.47] And all that to say is, a lot of this is about cooperation and making sure that everybody is cooperating in space to deal with these emergencies when they arise. And so I think cooperation and flexibility and just general international comedy are really important for making sure that even if we do have a lot of space debris, everybody's willing to work together to make sure that it doesn't create bigger emergencies.

[01:04:08.96] MILO MEDIN: Great.

[01:04:12.90] KEITH GREMBAN: All right. Unfortunately, Dan, I'm not sure I can get to you. We're out of time here. So I want to thank the panel. So thank you very much for all of this.

[01:04:24.51] [APPLAUSE]

Hatfield Endowed Professorship in Space Policy and Law Announcement

https://youtu.be/E59gO2ap8w4?si=Ooocpmwy-6uPGBQm

[00:00:01.13] BRAD BERNTHAL: All right. Phil Weiser, former professor here at the law school, currently our attorney general in the state of Colorado. When he founded Silicon Flatirons, he asked himself, in no small part, how does Dale Hatfield approach telecom and technology policy? And the answer to that he baked into our DNA. And you see on stage today, as well as at other Silicon Flatirons conferences, that is our approach is interdisciplinary.

[00:00:38.79] That these questions require economists, engineers, very importantly lawyers, social scientists and business people to be at the table. It also requires private sector voices, public interest voices, government voices and academics to be at the table. And that is very much in the spirit of Dale.

[00:01:02.83] And Dale, this center embodies very much your legacy in terms of work and technology policy. Today, Dale and Pat Hatfield are launching another legacy. Dale and Hat and Pat are stage left. Pat, would you please wave. Dale, we're going to further embarrass you in a minute. Yeah round of applause for them.

[00:01:29.66] [APPLAUSE]

[00:01:34.96] I see Stephen Hatfield there, the son here is Doug here as well. And Doug up there. Thank you for being here. It is my honor to announce that Dale and Pat Hatfield have given $2.5 million to CU Boulder to establish the Hatfield endowed professorship in space policy and law.

[00:01:56.96] [APPLAUSE]

[00:02:07.50] This new professorship will drive and support teaching and research on space policy and law across the CU Boulder campus. It will also support things like this, future conferences and events in this area. This work, as has implications for national security, global communications, navigation and weather forecasting, and international collaboration.

[00:02:32.16] Befitting Dale's approach and conviction that making good policy requires collaboration across disciplines. They have made this professorship interdisciplinary. It will rotate every two years between the College of Engineering and Applied Science, the Lead School of Business, and Silicon Flatirons in Colorado law.

[00:02:56.92] Reflecting this cooperation. I'm delighted to be joined today by Professor Dan Zhang, who is a professor from the lead school of business, and Mike Gooseff, Professor in the College of engineering. First, Professor Zhang, thanks for being here.

[00:03:11.21] [APPLAUSE]

[00:03:17.15] DAN ZHANG: Thank you, Brad. Today we celebrate not only the establishment of the Hatfield professorship, but also a powerful moment of convergence. One where disciplines, ideas, and opportunities meet at the crossroads of a critical global frontier space policy.

[00:03:40.10] Space policy today stands at a transformative crossroads. No longer the exclusive domain of governments or distant scientific endeavors. Space is rapidly becoming a shared arena of technological innovation, commercial competition, geopolitical strategy and international cooperation.

[00:04:03.38] The questions we now face, for example, about ownership, sustainability, security, ethics and access, demand more than one perspective. They require engineers, legal scholars, business leaders, and policymakers working together.

[00:04:24.28] This is precisely what the Hatfield professorship is designed to support. By rotating among the College of Engineering and Applied Science, the School of Law, and Leeds School of Business, this professorship embodies the interdisciplinary collaboration needed to guide space policy forward.

[00:04:46.07] We are deeply grateful to Dell and Pat Hatfield, who supported this vision. Your generous support ensures that CU Boulder will be at the forefront of one of the most important frontiers of our time. Thank you.

[00:05:10.41] MIKE GOOSEFF: I know I'm standing between you and lunch, so I'll do my best to be short, a bit brief. On behalf of the College of Engineering and Applied Science, I'm really delighted to express our excitement and support for this Hatfield professorship.

[00:05:22.95] A point of pride that we've had for the past several decades in our college, assuming nobody from my other departments is here, is the success and excellence that we've had in our aerospace engineering sciences department.

[00:05:37.14] The Department attracts top students from around the world, and they are all here to become the next leaders in the space industry. And teaching and mentoring those students is our world class AES faculty.

[00:05:50.85] Space, however, is no longer accessible to just a few countries, just a few players. And perhaps our successful history of training the next leaders in accessing space have to some extent generated the need for space policy and law.

[00:06:04.74] With this professorship, CU Boulder has the opportunity to be a global leader in developing fair and responsible approaches to space governance, and we're excited about that.

[00:06:17.23] I first met Dale a couple of years ago at an alumni event in Denver, and I had carpooled there with our Dean Keith Moolenaar, who's out of the country and couldn't be here, and he said, oh, who did you meet. I said, oh, I met Dale. And he said, oh, Dale has this really interesting idea.

[00:06:34.61] He's been talking to me about space law and policy, and I was struck by that. I just remember thinking I had never heard of something along that line before. And so it's particularly gratifying to me to see this come to fruition after a brief conversation a couple of years ago in Denver, in a car, no less.

[00:06:53.06] [LAUGHTER]

[00:06:54.88] I know of no other institution that's taking on this important challenge, and this professorship is a step toward complementing our expertise and reputation in space education and research to contribute to pioneering this new concept and directions in space policy and law.

[00:07:12.48] Finally, a note that this partnership among the law school, the Leeds School of Business and our engineering college is really emblematic of the collaboration required to forge progress in this new frontier.

[00:07:25.50] If I'm not mistaken, this is actually the first of the rotating endowed professorship on campus that-- that Brad described. And given that it's going to rotate two new faculty member every couple of years. Now, what's powerful about that is that the next person gets to build on the success, the thought advances, of the previous holder of the professorship.

[00:07:50.41] So this is really exciting and we look forward to the promulgation of an evolution of thought and contribution from these different thought leaders through time. We look forward to complementing our cutting edge advances in space research and education with a new shared strength in space policy and law.

[00:08:08.44] And nobody has said it yet, but the inaugural faculty member will be Marcus Hollinger from AES department in engineering. And Marcus is also out of the country unfortunately. But Marcus will be a perfect-- I think, first person to hold this and set-- set a new trajectory with this opportunity.

[00:08:29.19] So lastly, I just want to thank Dale and Pat for your vision and for your generosity. Thank you so much.

[00:08:37.74] [APPLAUSE]

[00:08:47.18] BRAD BERNTHAL: Thanks to Dan and Mike. Before we bring Dale up front and thank him and Pat directly, we would welcome it, if there is additional support for this professorship to increase its

muscle, increase its capacity to do work across campus, in addition to supporting the individual, which will rotate across the schools.

[00:09:15.07] This support will enable more work along these lines, whether it's here at Silicon Flatirons, at the Space Policy Center or other locations on campus. There's a QR code, if you want to get behind this, your contribution would be most welcome.

[00:09:29.69] Finally, it is really my honor to introduce the founders of the Hatfield endowed professorship in Space Policy and Law. Please help me give a warm and grateful welcome to Dale Hatfield and Pat Hatfield.

[00:09:45.72] [APPLAUSE]

[00:09:48.34] DALE HATFIELD: Thank you so much, Brad and everybody else here. I feel like I'm in a bit of a dream. I look out here at so many people that I've worked with over the years, and it just causes me to choke up, basically.

[00:10:05.20] I know I'm standing between you and lunch, so I'll just basically summarize it. Pat and I do have that strong belief in interdisciplinary activities. It's a way to solve problems and an expansive definition of that interdisciplinary it goes, includes diversity in all its-- in all its dimensions.

[00:10:31.50] I have a strong belief in the opportunities presented by space. But if anything, the first two panels this morning should introduced us to some of the challenges that we face.

[00:10:46.42] And hopefully my wife and my family were humbled by the opportunity to make contributions for the future of the students and the faculty and research here at the University of Colorado at Boulder, so we can make progress on some of these problems for future generations. So thank you very, very much.

[00:11:11.10]

[00:11:12.30] [APPLAUSE]

Keynote: Adam Cassady, NTIA Principal Deputy Assistant Secretary and Deputy Administrator

https://youtu.be/0n3AZLCMa1M?si=xuyLTmLLVwvEPlTB

[00:00:00.94] BRAD BERNTHAL: Doing the introduction, is part of a program that we have here called Startup Summer. As those of you who have been around Silicon Flatirons we operate within the triangle of technology, entrepreneurship, innovation, and law and policy.

[00:00:13.86] Startup Summer has about a 40 mutants who think that as undergrads, a good idea for their summer. Tuesday nights is to come to school and learn how to build a company. And Andreas is among those who is actively building a company and who I am calling a mutant. Andreas, over to you.

[00:00:31.91] ANDREAS WILWERDING: Good afternoon, everyone. Like Brad said, my name is Andreas Wilwerding. I am a fourth year aerospace engineering student here, and it is my honor to introduce our next speaker, Adam Cassady.

[00:00:43.76] He is the Principal Deputy Assistant Secretary and Deputy Administrator of the National Telecommunications and Information Administration. In his senior role, Adam advises the Secretary of Commerce and the White House on telecommunications and spectrum policy, playing a critical role in shaping the federal government's approach to managing and protecting our communications infrastructure.

[00:01:08.19] Previously, Adam served at the FCC in former Commissioner Simington's office, where he was chief of staff and senior legal advisor, guiding a range of initiatives across telecommunications, technology, and media.

[00:01:22.11] He also co-founded a machine learning technology firm and holds a degree from the University of Chicago. Please join me in welcoming Adam Cassidy to the stage.

[00:01:30.55] [APPLAUSE]

[00:01:35.67] ADAM CASSADY: So thank you very much for that. I don't know. So you said Chicago, but did you say the Ohio State University, which is far more important at any rate.

[00:01:49.47] So it's a pleasure to be here in Colorado. It's my first time actually. And thank God that I'm here right now, because otherwise I'm in DC. And so I learned recently, people say it's not the heat, it's the humidity.

[00:02:09.34] The reason is that once you reach a relative humidity index in the air, where it's like equilibrated with the moisture on your

skin, it no longer evaporates and no longer cools you. It's like 100 in DC right now, I think. Totally unlivable.

[00:02:31.28] So I'm happy to be here, where it's like in the '70s and mountains and things much better. I want to thank Brad and Keith and David and the entire Silicon Flatirons team for putting on this event and inviting me to speak today, but I want to thank Dale Hatfield specifically.

[00:02:53.53] So I had the good fortune of getting to know Dale when I worked for Commissioner Simington. And Dale was so influential on Nathan's thinking and my own. Nathan quipped that you could get an hour long conversation with Dale and leave with six months of agenda.

[00:03:17.61] It was actually a conversation with Dale and one of his colleagues, JP de Vries. That first got commissioner Simington thinking about harm claim thresholds in the context of receivers. Really interesting stuff for all of you, I'm sure.

[00:03:31.62] We got that proceeding passed and NLI into a policy statement. I think we'd love to see some further work done on some of the technical aspects of that proceeding. I don't know if I would call Dale an unsung hero because clearly plenty of folks sing his song, but I don't know if they sing it quite loudly enough. So again, a special thanks to Dale, and I'm very pleased to be here.

[00:03:55.27] I'm also excited to be in Boulder because it offers me an opportunity to visit ITS. Our world class spectrum and communications lab or at least it better be. I'm going to find out tomorrow. This is my first time there. If it's not a world class spectrum and communications lab, I'm going to turn it into one.

[00:04:14.20] It's called Table Mountain, and I gather that's because it's flat on the top. And so I go to ChatGPT and I say, Table Mountain, is that a butte? And ChatGPT is like, no, idiot. It's a mesa, obviously. And I'm like, Table Mountain, I get it now, that makes sense. I'm not Commissioner Simington. These things aren't just like, automatic for me.

[00:04:40.45] So sticking on that theme. So I'm a very different speaker than Commissioner Simington. I don't know if you've experienced him and myself, it's a bit of a different vibe. So sticking on that theme, I'm going to share a little story about commissioner. He's not in attendance today, which is good because he can't come up and hit me after this.

[00:05:01.88] I hope this won't embarrass him. I don't think it will. I'm here to talk about space, but this is what you're getting instead. So the commissioner and I were in LA one time. We were visiting a radio station group.

[00:05:15.26] And he arrived a little bit before me. And he's outside and he's pacing and he's like, up in platonic heaven. You're thinking, you're looking up as though that helps. I think it might actually.

[00:05:28.83] And he's like looking up and doing something. And I watch him for a while and I approach him like, Nathan, what are you doing? And oh, by the way, calling him Nathan is point of personal privilege for me. You all still call him commissioner, but I'm like, Nathan, what are you doing.

[00:05:42.87] And he's like, I'm memorizing Fourier transforms. I'm like, well, all right, that's cool. I memorized a couple of talking points about broadcast ownership caps. So that's the Commissioner he was and the talent he is. I'm sure I speak for most of us when I say, I can't wait to see what he does next.

[00:06:02.76] So anyway, sticking with ITS. I guess I know a couple of things about it. I'm going to learn more when I get there. One thing that I know is it has 9 or 10 miles of private road, and the reason that I know this is I recently approved a contract to remove like big stones and boulders from either shoulder on the road in the event of a fire. So that's one thing that I know about. It's got a lot of private road.

[00:06:29.58] It also apparently has an elk issue. It's called the elk problem actually at Commerce. And for me that's a little narrow minded. That's thinking small because we don't like to think in terms of problems. We like to think in terms of opportunity for transformational thinking.

[00:06:52.56] So I would prefer to think of it not as the elk but the elk opportunity. I'm being facetious or half facetious. Anyway, I'm looking forward to visiting ITS tomorrow. I'm looking forward to spending a large part of this conference with you today.

[00:07:12.11] So this conference is about space sustainability. I am no stranger to that topic. Really early on in Commissioner Simington's tenure, we offered up a bevy of options to then Chairwoman Rosenworcel to consider as it related to orbital debris. And she did, in fact, take one of those up the five year de-orbiting rule.

[00:07:30.15] Now, we can't take credit for that because I'm sure we were pushing on an open door. There was like a lot of consensus around this idea, but we did bring it up. And certainly, there are other great methods for ensuring future access to space, both commercial and scientific.

[00:07:48.96] In the space operating environment that make a lot of sense, I'm looking forward to hearing all of the good ideas that come out of this conference. And by the way, you can just call me with them to-- I try to be super easy to get a hold of--

[00:08:06.69] That was one thing that was important to Commissioner Simington important also to me. So if any good ideas come out of this that you feel like NTIA might be helpful with, please bring it up and we will try to be.

[00:08:21.60] One thing that I'll just throw out there for free, and this is an idea that people far smarter than me have, anything that we do that relates to orbital debris mitigation. In implementation, we have to parametrize the standards, meaning, bespoke one off evaluations of orbital debris mitigation practices, no matter where they happen.

[00:08:46.05] So it could be a commission. It could be a foreign jurisdiction, could be consideration in some international forum. Whatever it is, we have to push toward conditions that are easy to model and universally applied.

[00:08:57.87] That's not to say costless, that isn't to say toothless, but it is to say operators need to know what the rules are ex-ante. That's a tale as old as time. Just tell me what the rules are. So whatever the arc of the launch, I hope it bends toward predictability.

[00:09:15.54] So speaking of predictable rules, what I'm really here to talk about is American space dominance. America must remain the global leader in space, and it must expand its leadership. There's no alternative.

[00:09:28.79] Genuinely, if we cede ground to China, I think I view that as an unacceptable option. I think many in this room would agree. Like if we're concerned about space sustainability, I have very little faith that whatever norms develop under a China led international consensus won't lead to more uncontrolled rocket body re-entries that close down national airspace or what have you.

[00:09:50.51] So America must be full steam ahead. Or maybe I should say max thrust and stable burn in the space economy. Even if you don't care about America winning in space, and you should, you're here. What you must care about is who leads in international norms. And that should be us.

[00:10:09.23] So how do we do that? Well, from where I've sat at the Commission and where I do sit at Commerce, I have at least one idea predictable, reliable, and efficient access to the spectrum that commercial space operators, especially the earliest stage commercial space operators, need to succeed in their most critical version 0.1 Gen Alpha seed stage missions.

[00:10:32.73] The ones that determine if they raise another round, if they get that key CTO higher, if they land a key partnership, you know what screws them up. Waiting for months. Blame on us to coordinate with the federal equities or at the commission waiting to get access to an STA. Plenty of challenges on both sides of that ledger.

[00:10:56.84] And there's the coordination, the communication. There's a lot of opportunity for growth and improvement. And look, the rules that we have were built for a different era.

[00:11:15.31] It was under the auspices of ITU rules that were built for high, sparse, heavy, mostly state, individually launched satellites or

constellations and/or MEO orbit. The old world of space regulation didn't contemplate weekly launch cadences. It didn't contemplate commercial use, swamping defense or intelligence use.

[00:11:38.70] It didn't contemplate manufacturing in microgravity mining yonder asteroid. That's not anyone's fault. That's just the framework we're inheriting, a framework that made sense for its time.

[00:11:50.96] But we have to find intelligent ways to modify or overhaul completely that framework for a new rule, a new world. Because the stakes couldn't be higher for the coolest people in America, the leaders on the Space Coast, the truly sci-fi work being done in LA and Orange County.

[00:12:11.43] And you talk to them and they're like, hey man, can I bum an STA? Just one. Literally just one. I'll pay you back. Because these folks, they aren't hiring. I'm calling some people out, but Tremont or McDowell or whomever else is here or if they are, they're getting the friends and family rate.

[00:12:27.47] Because they aren't deep pocketed. They don't have a big gar office. They don't have ultra complex applications that can wait a year of churn before granting. They need to do just one launch and they need it next quarter. And it just can't wait.

[00:12:40.80] And if we make them wait, they're going to leave. Like literally ask them. Or maybe they won't leave fully, maybe they'll fly a flag of convenience somewhere else. Maybe a multiple exit founder will look at the US regulatory operating environment, say, maybe go somewhere else because that's happening. Talk to them. Don't take my word for it.

[00:13:03.36] But I think we can do better. The time is right. I'm launching an inquiry at NTIA to explore how to better coordinate with our federal partners most implicated by commercial space operation coordination, and with our partners at the commission to understand how can we start clearing some of this stuff.

[00:13:21.15] Bound up with that, and this I definitely can't take credit for is the multiyear IT modernization effort that NTIA has undertaken. Where we are looking to, once and for all, catch our own technology up to some of the cool stuff that we're authorizing. Not all the way up.

[00:13:36.61] Changing email submissions to structured data or-- that's low hanging fruit, but AI powered frequency assignments, we want to get there and we're working to get there. And we're excited to do it.

[00:13:51.07] And look, now, is the moment. If we are ever going to do this, I think this is our best window to act. We have an administration that wants bold, that wants to win, that expects good ideas.

[00:14:05.48] I've already had the good fortune of experiencing this now where I sit, and I fully expect massive wins from commerce. Our

team can contribute what might sound modest to some driving efficiency in the process of permissioning for spectrum asset access for commercial space operators. But for those to whom it matters, it matters a lot.

[00:14:29.02] So I can't wait to hear the interesting ideas from this commerce-- from this conference about potentiating transformation in the space economy, managing the growth of space traffic and orbital debris through cutting edge technology, tugs and nets and laser ablation and terrestrial tracking and space based tracking and automated conjunction management and a dozen other things besides. You all know far better than I ever will.

[00:14:53.39] But for our part, we want to help the American space commercial operators of every variety win and win big. That's how we usher in a new space age in America. And that's how ultimately, we transform space into the next frontier of industry and innovation.

[00:15:11.21] Government's at its best when it takes the most innovative sectors of economic development and doesn't just not stand athwart progress, but starts pushing from behind.

[00:15:23.18] I think we have an opportunity to do both. And as we kick off this inquiry, we welcome your ideas for how to ensure the next space age is American made. Thank you very much.

[00:15:37.40] DAVID REDL: Thanks Adam. Hi, everybody. I'm David Redl, the Founder and CEO of Salt Point Strategies and a senior fellow at Silicon Flatirons. And I'll be doing a brief interview to do some follow up questions on Adam's statement.

[00:15:49.80] I appreciated your story about the Boulder campus. I got yelled at. I got my first week on the job at NTIA, the mayor of Boulder was in Washington, DC, and asked for a meeting and I was like, God, this has got to be super important. I'm sure it's going to be something very important. It was a plea that we not put a fence up around the property.

[00:16:09.69] ADAM CASSADY: That's still an issue, by the way. The latest like update I got was, well, it's actually in the wrong spot. And like property law means that we like lost like a foot or something.

[00:16:23.88] DAVID REDL: It was trailhead access. That was the big thing for her. But yes. But it's nice to see that some things of great import are still happening at NTIA. So let's pivot to things that actually are of great import that are happening NTIA. You started with the general and worked your way towards specifics. Let's start with the general.

[00:16:39.98] You've been working in policy for quite some time, and now you've been in the principal Das role at NTIA and effectively running the agency in the absence of a confirmed administrator. So as

you've looked at how NTIA is approaching the space economy, what of your personal principles has animated your approach to the issues?

[00:17:02.00] ADAM CASSADY: Give me a second to think. I think that I really want to be led by engineering. So look. There's-- somebody technical, OCS is always going to get gored by policy that happens.

[00:17:21.75] And there's little that you can do about it. But at a minimum, if we can make the most technically supported policy choice and we can be-- we can have, let's say, the realm of what is possible, circumscribed genuinely by the technical experts.

[00:17:46.21] I think that's very important to me. And it's consonant with Commissioner Simington's thinking for those of you who know him, he was a deeply technical person, among other things.

[00:17:58.99] DAVID REDL: I have told many client that Nathan is going to talk to you about something in incredible detail. It might even be the subject of the meeting. And anyone that knows Commissioner Simington's will know he is a very deep thinker. And will talk to you about what he like.

[00:18:12.91] ADAM CASSADY: It was not the subject of the meeting. In fact, one time-- I get to just say these things out. I said, you got to stop filibustering your own meetings. We got it-- we got to get to the point. It was-- But he was just like endless curiosity.

[00:18:31.81] So if there's-- I think that is the most important thing and then secondary or maybe in partnership with that. What is the right answer for American interests? Meaning there are going to be some moments where there's some deeply critical federal equity that just is hands off. That exists. Y'all know it.

[00:19:03.19] And then there are some where it's like, can we play here? Can we think about how to get toward something that moves the American space economy generally forward? And I think that's another guiding value.

[00:19:20.87] DAVID REDL: Well, you talked towards the end about both thwarting progress and pushing from behind. I want to focus quickly on the thwarting progress. The Trump administration, Trump 45 and now Trump 47, both deeply committed to cutting regulatory burdens. At NTIA, how are you looking at-- what's under your regulatory machete, as you are looking to try to make things easier for the space industry?

[00:19:41.71] ADAM CASSADY: Well, what I would like to see is a focus on process. We're not a regulator. But we are subject to regulation. We're subject to statutory constraint.

[00:19:58.87] So is there a way that we can potentiate regulatory cut, let's say at the commission by being a more collaborative partner that is able to move quickly? Don't get me wrong. Everybody's got to

contribute to this new vision. But I do think so much of this is around process. It's so much of this is a process issue.

[00:20:29.83] Also, I will also say it is a resource issue as well. One thing that we're just going to have to consider is that OK, we're making some commercial operator do pre coordination with federal equities. Is there even anyone on the other side of that email address like-- because it won't bounce it.

[00:20:51.41] You'll think that your email went through to someone at some federal. And we said you know thou shalt pre coordinate fine. But then there's nobody actually on the other side picking up the phone or answering the email.

[00:21:04.64] And that is we gotta get that squared away. So that is one thing just making sure. And it's not a lot. It's like, a few folks. But we do need to make sure that we're resourced in that way as well.

[00:21:17.68] DAVID REDL: Well, I mean, the converse of that is what do you think is most slowing us down? I mean, obviously, process could be the answer here too. But I think from a regulatory perspective or which aspect of it do you think is most slowing or is most hampering our ability as a country to move forward and continue to advance?

[00:21:34.25] ADAM CASSADY: I mean, let's not-- I do want to say this, we do have the world's most dominant space economy. So let's not like act like, oh, you can't do business here in the United States. Yes, you can. And people have and people have found a way.

[00:21:54.33] And that's because we are broadly speaking, fairly pro-business. There's areas for improvement, of course. We also have the human capital. We've got access to and we've got access to the money. So it's not a bad place to do business. Let's start there.

[00:22:13.31] But having said that, I mean, where is the bottleneck? It's a cascade of bottlenecks. It's not-- there are-- I mean, if you were to look at it as a shape, it's like-- I don't know it's a Klein bottle. It's a weird looking bottle. And I wouldn't say it's not at the commission and it's not at NTIA.

[00:22:38.43] Again, I think a lot of this is honestly about process. Yes, there are probably ways that we can relax. Just for instance, multiple ground stations are they one or many? Are they handled?

[00:22:55.78] But having said, that doesn't mean that we can be uncritical about the implementation of these new like efficiencies. So yeah, I have 100 ground stations and I don't want 100 different applications.

[00:23:15.90] As I mentioned, wrapping some parameters up in that assessment. But what if, oh, I actually have 100 but these three I'm behaving a little bit differently there. We have to have some flexibility in order to do those assessments as needed.

[00:23:38.43] But pushing toward a framework that is about parameters, that is about asking forgiveness rather than permission, not on critical, safety of life stuff, but on other things. I think that's where we're trending, again, being thoughtful about it, being smart about it.

[00:24:00.60] DAVID REDL: I mean, to pivot to the other side. Then from the push from behind side, you mentioned in your remarks that NTIA is going to begin an inquiry on these processes. What are you hoping to hear from the public on how government can help push from behind?

[00:24:15.37] ADAM CASSADY: They know better than we do. I mean, almost by definition. So you've-- so I don't know how many of you know Peter Dohm. Maybe many know. But just-- if you're on the outside of government and you've lived the friction of government and you can bring, I will tell you that the most powerful thing that you can do when you set a meeting with anyone in government is tell a story. Tell your story.

[00:24:46.97] Tell how something-- and the leave behind has the action items. The leave behind has-- Here are the technical reforms that could have helped. That's great. But what you need to do is come in and say, hey, you delayed my launch. I missed my window. I didn't get on that Falcon, and I didn't raise my next round. What are you going to do about it?

[00:25:09.73] That is-- and you're going to live that reality every single day. So you know better than I do. So I'm not coming in here with a bunch of preconceived notions about how it has to be. What I have to do is learn how it is.

[00:25:25.39] DAVID REDL: And I think that plays importantly to the role NTIA plays in the interagency that I think gets overlooked a lot in this space and pun intended space in this area of law, which is NTIA is an economic agency at its core.

[00:25:38.09] It is not I mean, the Office of spectrum management will Lynnette can kick me on the next panel is not, by its nature, a technical organization. The spectrum management team are obviously very, very technical.

[00:25:48.71] But it grew up as an agency to advise on economic policy around telecommunications. And so I think as you were looking at that, if you could pick one area of the space economy that you think is the most ripe for the Trump administration to just double down on, which piece do you think is the area that you think is the most ripe for that to take off?

[00:26:11.96] ADAM CASSADY: I mean, honestly, I'm so my own bias is toward I am startups. So we've got a very interesting--

[00:26:21.50] DAVID REDL: In-space assembly and manufacturing.

[00:26:23.48] ADAM CASSADY: We've got a very interesting proceeding at the commission about how to potentiate growth in that area. But I do think that if we're going to create a space economy, what that means is moving the space opera-- moving to the space operating environment as a place where the real economic work of America gets done.

[00:26:48.06] So for me, that is by far the most interesting thing. All love to putting up another telecommunications satellite and all of that. That's great. We need that. We're doing that. But we're already doing that. We're doing that super well actually.

[00:27:02.96] DAVID REDL: Tens of thousands.

[00:27:03.72] ADAM CASSADY: Yes. So let's do other stuff. Let's make drugs in space. Let's go mine asteroids. Let's do that stuff.

[00:27:15.43] DAVID REDL: It's almost like you read the agenda and what the next panel is going to talk about. So I appreciate you teeing up the panel that comes next. I will close with the one thing I always hated to get asked, but it's also a softball for you, which is if you are running an agency, people invariably ask if you could wave your magic wand and change one thing in your jurisdiction, what would it be?

[00:27:39.85] ADAM CASSADY: Oh, boy.

[00:27:40.55] DAVID REDL: And I'll tee this up by saying, I used to answer. I'll give you time to think. I used to always answer IT, because I'm glad you guys are getting there. Because when I was administrator, not 10 years ago, we still and I think they may still be running some of the spectrum access databases on Visual Basic, I'm not kidding.

[00:27:55.61] I wish I was kidding. They're emulating a 486 because they don't even have a computer that's capable of running it with the right clock speed anymore. That is a true story. So I gave you a couple minutes to think about waving your wand. So if you could wave your wand and change one thing in your jurisdiction, what would it be?

[00:28:11.04] ADAM CASSADY: This is not even going to be an-- I'm sorry. This one's not going to be interesting to you folks and I do apologize. But departmental rules require political clearance on an ungodly number of documents. And so there's just like, it's like every day, a dozen, two dozen. Hey-- I come back to my desk. Hey, it's like 100 pages of stuff that I've. I don't even know what it is. I need your clearance on this by 5:00 PM.

[00:28:45.12] DAVID REDL: The sweet irony of a bureaucrat complaining about bureaucracy, I love it. There's no better way to end the panel. Although you did say you wanted to be in touch with people. So we're to put your home address out to everybody. It'll be fine. But please join me in thanking Adam for coming and joining us today.

[00:28:59.30] [APPLAUSE]

Panel: Navigating the Final Frontier | Contemporary Challenges in Space Governance

https://youtu.be/ezwhWd3m5tQ?si=31CgwtxvgShYdY7S

[00:00:00.89] DAVID REDL: In the collective failure that is my inability to get this panel ready, I was told, or at least I thought, that there was going to be a student introducing the panelists, but I am doing the introductions instead. So guess what? You're all going to get very truncated introductions.

[00:00:13.28] Jennifer Warren is here to join us from Lockheed Martin. She has a very fancy vice president, regulatory, and something else title, literally. I don't have any of that stuff in front of me, but it's on the screen for you guys.

[00:00:24.74] Lynna McGrath with us from NTIA's Office of Spectrum Management, which I just maligned on our previous panel. So I'm sure she's really going to be happy to see me moderating on this one. And Dan Baker from the University of Colorado.

[00:00:35.49] We are going to jump right in, because unlike what you heard right before the lunch, I feel like starting with a John Cleese quote. And now, for something completely different, I think we're going to have some contrary opinions on this panel.

[00:00:50.01] So I'm just going to jump right in, and we'll start with the broad. And I'll start with Lynna, because you're right next to me. From a US policy standpoint, what's the most pressing government challenge that you're facing in the Office of Spectrum Management right now?

[00:01:05.03] LYNNA MCGRATH: Probably balancing the needs of everyone who wants spectrum access. So we're sitting here and we're talking about space. How many folks work in the space economy and need access to spectrum? I'm seeing no hands.

[00:01:20.22] DAVID REDL: Yeah, so if you don't put your hands up, you've waived your right to spectrum later.

[00:01:24.20] LYNNA MCGRATH: So we've got this growing, increasing demand for access for space systems. We have this growing, increasing demand for spectrum for satellites or for terrestrial systems. And I got asked the question earlier today on mid-band spectrum and the impact on satellite.

[00:01:41.87] We've now seen two worlds collide. So if you look at what's being teed up for mid-band, and what's being studied in the ITU agenda item 1.7, looking at additional spectrum for IMT 5G60, for those of you who don't speak ITU, bands that are teed up include bands that are used for satellite.

[00:02:03.96] So are we going to take spectrum away from satellite companies, and give it to terrestrial? That's a question. So we keep having this growing demand for everyone. As I keep joking, I've seen the enemy, and the enemy is myself. How many mobile connected devices do you have on your person right now?

[00:02:25.38] DAVID REDL: Very few of you are going to say one. Let's be honest. Dombrowski, you're throwing off the curve.

[00:02:31.02] LYNNA MCGRATH: So it's one of them. We're all having this incredibly increasing demand for additional commercial services. We've got all of this we want to do. We all want to be wireless. We want self-driving cars.

[00:02:44.83] We like it when our car beeps at us and tells us, hey, there's somebody in your blind spot. Don't pull into them. We like it when we get accurate weather forecasts. All that stuff requires spectrum.

[00:02:58.30] So we've got this incredible increasing demand and no additional supply. So how do we find the balance across all of the users, both federal and non-federal, to meet everything we want to do? So that's probably our biggest challenge.

[00:03:12.88] DAVID REDL: Yeah, not surprising that that's your biggest challenge. I think we heard a little bit about that on the earlier panels. And the answer has always been right. Of course, we'll take from satellite and give to terrestrial because that was the way the ratchet went.

[00:03:24.07] And it seems that things are starting to maybe turn the other direction. I guess we'll have to see. Dan, your work has focused on the proliferation of satellites. And so from that regulatory perspective, what are you seeing as the biggest challenge of the proliferation of satellites?

[00:03:39.21] DANIEL BAKER: Yeah, in a classic paper in Science magazine in 1968, Garrett Hardin talked about "The Tragedy of the Commons." Individuals acting rationally and in their own self-interest will deplete a common resource, even if it hurts the group as a whole.

[00:03:57.90] And that's what really concerns me, is that I don't know how many satellites the system can bear, but I know as a scientist, it's having a tragic effect on astronomy. It's affecting radio astronomy. What is really concerning is the possibility of a collisions that will make an entire region of space unusable.

[00:04:21.57] So it's a $400 billion plus industry, and it's essentially the Wild West. And Commissioner Gomez talked about some different models. It could be self-regulation.

[00:04:36.64] Everybody does the right thing, maybe. That maybe there could be national leadership. And that would be the US at this

point, taking leadership and setting the tone for others. Or it could be some body like the United Nations.

[00:04:51.49] The United Nations has disavowed its interest in enforcing or establishing real rules. They'll just be a source of transmitting information from one group to another. So my big concern is what process is put in place in order to regulate and to assure that we don't end up with a large region of space that's essentially unusable?

[00:05:18.18] DAVID REDL: It's great. Jennifer, your company actually builds orbital satellites and helps get them up into orbit. So maybe you could give us a little taste of what from Lockheed's perspective, you're seeing as challenges and opportunities in the current congested environment.

[00:05:32.56] JENNIFER WARREN: So I'm just going to take it in a slightly different.

[00:05:35.58] DAVID REDL: Listen, I knew no matter what I asked you, Jennifer, you were going to answer the question you wanted me to ask because that's great.

[00:05:40.18] JENNIFER WARREN: Oh, yeah. So I'm glad we got that. So thank you, though, for having me anyway. So I think one of the challenges that's out there is one that I don't disagree with anything that folks have said, but it goes back, how do we make the US the best place to be licensed and going forward? And that is getting rid of some uncertainties.

[00:06:00.75] And there's been an uncertainty that, I think, unlike some of these issues where industry is divided, there's an uncertainty where industry has not been divided. And that is with respect to implementation of Article 6 of the Outer Space Treaty. And where does supervisory authority for activities in space reside? We know where the RF authority resides. We know where the--

[00:06:25.07] DAVID REDL: Jennifer, you want to elaborate on Article 6 for the law students.

[00:06:27.87] JENNIFER WARREN: Article 6 requires that state parties to the Outer Space Treaty exercise supervisory and, it's not the right word, regulatory authority over activities in outer space that are basically performed under the national administrations licensing.

[00:06:46.56] And since, probably, President Obama, industry has reached out with seeing all the new cool in space activities that were coming whether ISAM, which has already been defined or any of the other really cool new activities that are taking place in space.

[00:07:07.93] So where do we go for that, what we call mission authorization? And that still is an open question despite all the

leadership and all the success. And I think the word was, dominance, that Adam used. Still, that's an open issue that creates uncertainty.

[00:07:24.29] So industries have been able to work around that. And we've gotten the FAA to step in at times. The FCC has been willing to step in, but there's been no clear representation of where that authority resides.

[00:07:38.61] The last administration came out with a proposal for human flight, human activities in space to be regulated by the FAA and non-human by commerce. There was a completely different approach that was being floated in legislation.

[00:07:53.87] We're still sitting here without that clarity. And when you want to get a mission authorization, so you as a commercial entity, know you're covered and deemed in compliance with the provision that every country in the world that signed it, which is a lot, recognize you're sitting there.

[00:08:11.84] So I think that's an area where it would be really helpful for that predictability and certainty for us to be able, as a country, to move forward. But that requires everybody working together, Hill executive branch and industry.

[00:08:28.15] DAVID REDL: Lynna, the Department of Commerce is obviously, as Jennifer pointed out, a player in this space, and has a role in here. What have you been seeing in terms of the way that the Department has been trying to change processes to address the concerns that we get things done, and get things in orbit faster? Have you seen a process change at all in the last couple of years?

[00:08:47.41] LYNNA MCGRATH: So I think one of them, and as Jennifer alluded to, there's been a lot of conversation of who's responsible for what. So in the Department of Commerce, we have the Office of Space Commerce, which is in NOAA. Because that--

[00:08:59.44] DAVID REDL: Was it back in NOAA now?

[00:09:00.56] LYNNA MCGRATH: Yes.

[00:09:01.00] DAVID REDL: OK.

[00:09:01.43] LYNNA MCGRATH: That makes perfect sense. We put Space Commerce in NOAA. So they're working on, as the previous panel mentioned, they're taking over responsibility for the coordination and tracking of existing space systems. So we have that going on.

[00:09:19.74] I'm trying to work on that. But it is challenging of trying to figure out who's responsible for what. And it would, from a federal government perspective, providing some clarity of what's in who's job jar such that we're not stepping on each other's toes or running into the situation of someone develops rules, and then gets taken to court,

and has it thrown out, leaves all, goes straight back to that predictability and certainty piece.

[00:09:47.04] So I think there's a lot of work being done. I know in OSM, we're really focused on, as Adam alluded, trying to fix the satellite coordination process for his different companies come through and want to access federal or shared spectrum.

[00:10:01.64] We can make that process smoother. That's an ongoing effort to figure out how to do that. So there are things we're doing, but it would be nice if we got some direction from the administration and the Hill of what falls and who's job jar such that we have direction on the federal side of where we need to go.

[00:10:20.99] DAVID REDL: Jennifer, from the commercial perspective, the space traffic management efforts that have been made, is industry getting what it needs at the timing, or is industry simply filling the gaps that exist in the government's current portfolio?

[00:10:34.94] JENNIFER WARREN: So yes and yes. So I think tracks and the space data association as well, which a lot of industry US operators in particular like, does fill the gaps, and does start to pick up what DOD is transitioning out of.

[00:10:52.92] But one of the challenges that, because even though we have so many of the next generation satellite operators coming out of the United States, there are still lots, as was discussed on prior panels, coming from a lot of other countries.

[00:11:08.97] And there is a sensitivity that a US-based tracks-like entity may not be where some countries want to share some of their data, their ephemeris data that will tell the US government where their satellites may be, depending upon the mission of that satellite or that constellation.

[00:11:29.43] So there's a question about, particularly for the full picture of the value of tracks. How do you then globalize that? How do you get operators who might not want to share with the US entity that data?

[00:11:44.37] What sort of neutral environment can there be? Is that, and I'm not picking one. I'm just throwing out. Is that an ITU? Is that some sort of NGO? What kind of model is that? So whether it's the Chinese, the Russians, the Americans, the Indians, the Brazilians, everybody will want to share that.

[00:12:05.13] Because as we've talked about before, this is a Commons in the sense that there are no lanes. There's no sovereignty. Constellations are flying. Doesn't matter what flag you're flying. But that ephemeris data and other data is really relevant.

[00:12:19.56] So how do you create that environment? So I think everything the US is doing is very important. But taking it to that next

level that it's truly globalized is something I think that we still need to focus on as a country.

[00:12:32.46] DAVID REDL: And do you think that's, given that space is actually a warfare domain, do you think that's even possible?

[00:12:40.56] JENNIFER WARREN: I think it's possible to do more than we are doing today. It doesn't mean that ephemeris data from every system will show up into that database, but more will come than perhaps will come today.

[00:12:54.96] DAVID REDL: That's fair.

[00:12:55.54] JENNIFER WARREN: At least this is, I was just on a call yesterday with operators on this topic, so I know it continues to be a concern globally.

[00:13:03.10] DAVID REDL: Yep. Dan, from your perspective, is the data that's out there in terms of the amount of what's in orbit in terms of both space traffic management and in terms of debris mitigation. Do you think there's-- where are the gaps that you're seeing from an academic perspective that are not being met by either government or by the private sector?

[00:13:21.57] DANIEL BAKER: Well, I would say that there's a lot that we know and a lot we don't know. And we know the larger objects, but all it takes is one major storm to disrupt the knowledge about what's there.

[00:13:36.10] The earlier panels have talked very interestingly about what's necessary in order to deal with the increasingly crowded space. And I think I agree with the things that were said before that we need to have better knowledge about where things are. We have to have better precision for that kind of information at all.

[00:14:00.34] But my question, I guess, is whether that's coming along rapidly enough. The sauce function is increasing exponentially. We're getting more and more things in space. I think that's going to, maybe that's the theme I'll hit repeatedly here, is that it's just getting to be too crowded and too dangerous.

[00:14:19.86] And we're one major catastrophe away from making things really, really bad. And so I think from an academic standpoint, we need to increase all the techniques that have been talked about. We need to make sure that we provide more information for operators. We need to have more alerts.

[00:14:44.17] But there are so many things in space that can't move, that can't get out of the way. I think there's a real danger lurking here. And I hope from my point of view, somebody's got to step up and take leadership.

[00:14:59.17] I think the United States has got to do that. I agree with the points made here that we need to get government agencies to understand what their roles and missions are, and then take those seriously and seek to get the rest of the world to line up behind us.

[00:15:14.61] JENNIFER WARREN: Can I just add one more thing. And this keeps coming up. And Kim, I'm going to give credit to you for always raising it in bilats, but it continues to come up. Something as simple as a contact list.

[00:15:27.87] For operators to know whether it's IMing, someone texting them, phoning them, not emailing, but about collision questions or issues, that is missing. Something as simple as that. And having something where you start to create.

[00:15:46.48] We go back to culture, the lady from the humanities. The culture of connecting on something as simple space has always been kind of above in many ways, tensions around the world in a lot of ways.

[00:15:59.68] And so creating that connection between operators and having a contact point that survives change, retirements, and what have you, so that operators develop that familiarity is another way to create a safer environment for more and more investment. Because let's face it, it's about cool things, but it's also about a safe place for investment.

[00:16:21.34] DAVID REDL: Yeah, like all of the cool areas it's the mundanities of, literally, do you have somebody to talk to that actually drive the advancement. I'm going to take us from low Earth orbit, and I'm going to try and be like the Apollo program. I'm going to take us a little further out and around the moon and maybe back if I do it right.

[00:16:39.11] So I wanted to move away from the shell right around the Earth and talk a little bit about governance around objects that are near Earth, but not part of Earth. And so let's talk about resources and gathering resources in outer space.

[00:16:54.86] And Jennifer, I think this might be a good one for you to start with. Look, we have, obviously, we have the Outer Space Treaty, which talks about the ownership of objects in outer space.

[00:17:03.92] We also have various countries around the world deciding that they're going to put mineral rights laws on the books. From an industry perspective, how do you navigate that particular challenge? And what should we be doing to square the circle?

[00:17:20.32] JENNIFER WARREN: So a few things. Obviously, you're not appropriating land on the moon, you're extracting, which is a little different. And if you look at, I'll go back to the reference to on close earlier.

[00:17:33.46] On close is a really great cross-reference when you look at ocean minerals. You get licenses for extraction of minerals from the

deep seabed in international waters. Doesn't give any entity title or sovereignty over that area. All it does is create a right to not be disturbed in the activity, the specific activity that you're undertaking.

[00:18:00.46] I think there's a great analogy between how you could look at asteroid mining or any other resource acquisition, if you draw from that, and how that's been implemented, at least in concept, through the International Seabed authority's implementation of part eight.

[00:18:23.07] DAVID REDL: Lynna, we don't get out there, and get to the moon without having access to spectrum resources beyond orbit. I know a lot has been discussed about lunar spectrum and cislunar spectrum. Maybe you could give the crowd a little bit of a primer on what's happening, and where things are headed with spectrum governance in those spaces.

[00:18:42.58] LYNNA MCGRATH: Sure. So it's one of them of, I think we keep joking in the ITU, it's not when the first country lands on the moon, it's when the second one gets there that we're going to have problems.

[00:18:53.95] So right now, there's several conversations going on within the ITU. There's an agenda item for one dot or for WRC-27, 1.15, which starts looking at lunar spectrum. So what are the requirements for lunar spectrum, or for lunar spectrum communications, PNT, all that sort of stuff? We're going to need that on the moon.

[00:19:19.73] So what are the initial requirements that we need? But then, also, that item has in there of what's the appropriate framework we should be using for this? There's been conversations in the ITU about adding ITU region four.

[00:19:36.00] So if folks aren't familiar with the ITU, we've broken the world down into three different regions. We've got the Pacific kind of Europe and Africa, and then we got region 2, the Americas, creating ITU region four, which would be lunar.

[00:19:51.86] So you have those conversations of, is this something we should be doing? And then it gets down into the whole thing of the ITU is not an enforcement mechanism. It relies on the sovereignty of the nations to basically do their own spectrum management. So who does that for the moon?

[00:20:12.11] So we've got a lot of these things going on of earlier panel of it's the right now by ITU definition, anything in space is considered a Space Station. So if you have, say, a rover on Mars, it is considered a Space Station.

[00:20:30.29] As we're starting to get into building out ecosystems further outside of the Earth and its orbits, what should we be doing, and how do we regulate this? And that's a lot of the conversations that are going on right now. Like I said, it's not when the first country gets

there. It's when the second one gets there. We get number 3, and that's when we start having these conflicts.

[00:20:54.57] So there's a lot of conversations going on, and I have a feeling that this is going to be a recurring agenda item for, Lord knows how many upcoming WRCs, to figure this out, because the problem is going to get here sooner than we think, and we'll see if we can get the regulations in front of it or if we're playing catch up.

[00:21:15.12] DAVID REDL: Who besides the United States are the players in this game right now at the ITU?

[00:21:19.19] LYNNA MCGRATH: So in a lot of cases, and one of the things that's different, I think we're seeing a change in how lunar is approached, is it used to always be science and it was being done by the different nations.

[00:21:33.30] Now, we've got private companies getting involved in this. So we've seen Japan has had tried to do lunar landers. We've got India is working on lunar landers. China, obviously, is trying to go to the moon. So we've got a whole bunch of different countries involved in this.

[00:21:50.01] But the thing that's actually been kind of fun working in the space science area is amazingly, for the most part, those countries work well together. So there is a, I call it a coalition of the willing. Many of the world's space agencies get together as a part of what's called the Space Frequency Coordination Group, SFCG, and work through these issues.

[00:22:13.20] So there, actually, is an existing lunar frequency plan using existing allocations from the Earth. Where do we have space research and space operations allocations that could be put forward for use in lunar? How do we line those up to ensure that we don't have two countries trying to ask for the same frequency and have overlaps? Yes, we have had spectrum conflicts on Mars.

[00:22:42.02] So how do we get away from that? So right now, it's kind of been this coalition of the willing, but that's been primarily national space agencies. We're now bringing in the private sector, which is interested in getting in operations here. So it's figuring out how to play in that. And it's one of them of it's very interesting. As you see, a lot of the world geopolitics don't tend to play there.

[00:23:04.68] In those conversations, the US and Russia actually gets along really pretty well. China is a part of those conversations. They tend to be quieter, but they are there. We're not totally sure if they're going to adopt the SFCG approved frequency plan.

[00:23:21.98] From what we've seen, they may be going their own direction, but there has been discussion in trying to get this aligned, just kind of as that coalition of the willing. But as we get more people involved, more companies involved, it's going to need to expand, and

end up in some probably regulatory framework to protect everyone's interests.

[00:23:43.26] JENNIFER WARREN: I just want to mention, because it's really important. It's the opportunity side. So all of the companies that are trying to participate in what will be the lunar ecosystem, if you like, we're trying to take a lot of what's happening in digital technology development on Earth, and see how to leverage that and use that on the moon so that we're not having to recreate things.

[00:24:07.98] So what we're seeing is we're trying to take terrestrial mobile technology, move it up to the lunar surface in the same band that they're actually optimized for here. So it creates some interesting confusion because the terrestrial mobile wireless sometimes thinks, well, wait, if it's going to be space, that's going to be in conflict with us, and we're like would have to have so many millions of terminals on the moon before you even see a blip on Earth, that I would love to see the ecosystem evolve that quickly or in the next 20, 30 years.

[00:24:46.45] But we're talking about way far out. And your technology is the terrestrial mobile technologies, will evolve maybe to another band by then. So we don't see the saturation of a band on the moon coming at the expense of anything on the Earth, but instead the OEMs, the terrestrial equipment manufacturers will actually benefit because it'll be a new market for their technology optimized for the band that they've optimized here.

[00:25:10.93] So there's a lot of synergies that are between the two space and terrestrial that can really be manifested up there. So we don't have to export the spectrum awards to use Jennifer Mander's book, to the moon. We can just keep them here on ground.

[00:25:25.62] DAVID REDL: Dan, I'm going to turn to you briefly because I'm in a room that I'm painfully aware is full of astrophysicists who will attack me if I don't bring up the radio astronomy issue, and I know it's an issue you care a lot about. So maybe you could pivot to radio astronomy, and the impacts on them.

[00:25:40.41] DANIEL BAKER: Yeah, first, can I just comment on--

[00:25:42.46] DAVID REDL: Go for it.

[00:25:43.65] DANIEL BAKER: I want to have a lament here as a scientist. Things were a lot simpler, in some ways, when we had COSPAR the committee on space research. And this was an organization that dealt with state entities, state aid, space agencies.

[00:26:01.54] And really, even during the height of the Cold War, I guess people could still talk about things and work things out. And now, in this new world, things are much more contentious between state players, and there are many more players private industry, and so on.

[00:26:21.28] I don't think there's a similar kind of entity that really facilitates as much conversation as there needs to be, and I would like to hope and think that we could get back to a time when no matter what the political differences, no matter what, that there's still enough self-interest that everyone would get together and work things out in a more peaceful and coherent way.

[00:26:46.24] DAVID REDL: I mean, we could do an entire conference on should we have multilateral or multi-stakeholder governance of space, which is the topic you just teed up.

[00:26:54.13] DANIEL BAKER: Yeah, I know this. We can get off into all kinds of things. Now, what were you asking me before?

[00:26:59.68] DAVID REDL: I was asking, I was pivoting to some of the radio astronomy challenges of more and more radio use in space in addition to what's happening on Earth.

[00:27:08.44] DANIEL BAKER: And there's an interesting chart that was put together just looking at the effects of leakage from satellites, what that's doing to the radio astronomy bands. The radio astronomy signals may be a hundredth of a jansky or something like that. And there are hundreds or 1,000 jansky kind of signals coming from operating spacecraft. It's just devastating.

[00:27:32.09] And these are occurring in the bands that are supposed to be clear for radio astronomy. So somebody's got to take charge of these things. Somebody's got to work with the offenders and try to figure out.

[00:27:48.41] And I think, again, I hope that Silicon Flatirons, and maybe our new Space Policy Center, can convene people to sit down in a room and to talk reasonably together about what's going wrong here. What technological solutions can we have.

[00:28:05.90] I don't see any way to get the genie back in the box on the proliferation of communication satellites and stuff that's not going to happen. So how can we deal with the problems and still preserve radio astronomy, and for that matter, nighttime?

[00:28:21.55] DAVID REDL: Yeah, space as a domain is certainly not immune from the challenges of how to address passive users that we experience on terrestrial. And I would throw up to the group, if there's an idea amongst any of you about how to strengthen the role or the voice of passive users in the governance model we have in a way that doesn't harm our space interests. I'm off script now, guys. So if they don't answer, it's OK.

[00:28:45.28] LYNNA MCGRATH: It's a challenge. And you've got the radio astronomy folks, but when you talk passive, it's not just radio astronomy. We've also we do a lot of science measurements, using passive sensing. So a lot of the data we get to go and feed into our weather models comes from passive sensing.

[00:29:04.81] And those are our bands that are under pressure. We see filings to the ITU which say the passive sensing bands are the biggest waste of spectrum that is out there. So you've got this tremendous pressure.

[00:29:19.01] We got a question earlier about, there was a current FCC proceeding, which is looking to put terrestrial service, or which is looking to put space services in an existing passive sensing band.

[00:29:31.16] So you've got this dynamic tension. As we noted, we're looking for more spectrum, what's available. You've got these bands that laws of physics say you can't move, but everyone wants to get tighter and tighter and tighter up against them. And it's a challenge. And with those, the big thing we're worried about is insidious interference.

[00:29:55.25] So it's not one of them of you can look at it and go, that ain't right. So if you look outside and it says the temperature outside is currently 212 degrees, you know that's not right.

[00:30:08.80] DANIEL BAKER: Pretty close so.

[00:30:09.82] DAVID REDL: You hope. I mean, none of us are in DC right now, but it's pretty warm.

[00:30:14.15] LYNNA MCGRATH: But what if it's off by 1%, 2%? You start getting these very slight increases into that data. That's now what we're feeding into, say, our weather models. What's the impact of that?

[00:30:32.18] So we've got this challenge of trying to do more with the existing spectrum we have, but protect some of these very critical uses that it's spectrum, we don't auction, we don't sell commercial service in, but has tremendous value to the American public.

[00:30:53.16] So it's a challenge of how do we protect those because it's difficult, and we're trying to do a lot more with less, but make sure everything still works. And here's hoping technology continues to develop, and we're able to do that. But it's a really hard challenge.

[00:31:13.08] DANIEL BAKER: But that's what I think.

[00:31:14.87] LYNNA MCGRATH: No, go ahead. No.

[00:31:15.69] DANIEL BAKER: I was just going to say that's what's great about having meetings of sort that Silicon Flatirons has organized, where you have lawyers, you have agency folks, you have scientists, you have engineers, you have all the people who are affected, maybe intended and unintended consequences are looked at.

[00:31:36.60] And you got to recognize all the realities, but you have to find a path that minimizes the harm to all parties. And it's not going to be perfect for anyone, but it's going to make it a lot better.

[00:31:51.71] JENNIFER WARREN: So I think one of the challenges is there's no one that's willing to do an economic valuation of citizen services. What's the economic value of a service that services all of us at no subscription cost? I can't find an economist who wants to do that. If anybody here does, let me know. Thanks.

[00:32:15.92] DANIEL BAKER: Good.

[00:32:16.58] DAVID REDL: I will take us on that note. I'll take us back out into orbit and pivot, because you brought it up a little bit ago. And we've talked a little bit about this sort of dichotomies that we're facing here. Like you said, Jennifer, earlier, everything, I think it's you Jennifer, everything in space is a Space Station. And we treat everything in space like a Space Station.

[00:32:34.02] And, Jennifer, you brought up in space assembly and manufacturing, which is presenting some unique questions about what do we do as we look at a governance model that looks at things with more strata than we currently do? How do we address the differences between human cargo and non-human cargo? And yes, I realize I just said human cargo. How do we look at things that are--

[00:32:58.90] JENNIFER WARREN: Us humans.

[00:33:00.83] DAVID REDL: Let's be honest. They're cargo until they get up into orbit. Come on. And how do we deal with the fact that we've always treated rocket stages like rocket stages? At what point does a rocket stage become a satellite? These are all questions that are being tackled right now. Lynna, can you talk a little bit about what's being looked at in the government from that perspective?

[00:33:22.91] LYNNA MCGRATH: That's a good question.

[00:33:24.53] DAVID REDL: I mean, like, I tried to, I realize I'm asking NTIA about an FCC proceeding, but I was the reality that the US government is starting to look at ISAM.

[00:33:32.79] LYNNA MCGRATH: No, it's very much we're starting to look at ISAM. And I think it's kind of been said ISAM covers such a broad range of different uses. So you have everything from manufacturing to developing, or trying to do maintenance on satellites.

[00:33:56.43] So it's the what, and they need spectrum for different purposes. So what is it? And I think one of the ongoing conversations we have is, well, what service class does that fall in? And going, huh, this doesn't really fit any of them.

[00:34:17.89] And no one ever wants to open Article I at the ITU of definitions because that is opening Pandora's box. But it's getting into that. Where do these fit? And do they not fit in our existing allocation table, and our existing service classes? And if so, how do we treat them?

[00:34:40.21] And I think that's what the FCC is ongoing. ISAM proceeding is it's such a new and evolving economy, and it covers such a broad range of topics and broad range of uses that it's really hard to figure out where to go right now.

[00:34:58.57] I think it needs, it's so new. It's how is this going to emerge? And I think that's the tact the commission is taking with this, is looking to see how does this economy continue to evolve. There's going to be different economic drivers.

[00:35:14.32] I love the person who said, on the previous panel, that economics gets the second to last vote, because it's very true. And I think it's going to be one of them of what's the financial base, what's the economic drivers for the ISAM economy?

[00:35:30.07] And I think as you see space sustainability, if there's going to be space sustainability requirements that come in, is that going to push different portions of ISAM? So as you start to see how does this unfold from an economic perspective, I think that will help determine where we need to go. But it's still so early. It's really hard to tell.

[00:35:52.03] DAVID REDL: Dan, you've done a lot of research on space debris and the ISAM question that Lynna just teed up. What is this going to do to our sustainability question? How have you been looking at ISAM, and what its impact might be going forward?

[00:36:05.85] DANIEL BAKER: Well, let me answer the question this way, I guess. I'm very excited about the possibility from the previous panel of being able to reuse things, recycling, take materials there, and use them for other purposes. That's very exciting.

[00:36:32.92] What worries me is that this is developing too slowly, and the source function is increasing exponentially. And the loss, the reduction is taking place too slowly. And I really believe that only government, I think, can really seed this adequately in order to move this, I increased the pace of development in this arena.

[00:37:04.16] And again, the things we've heard about some of the threats to government support are diminishing rather than increasing. So I'm just raising another, there are plenty of alarms being set off by many things, but I really think this is moving along too slowly. The whole all the concepts of debris removal and reuse, and so on, are really not moving adequately, rapidly to deal with the problem that's developing in the aerospace.

[00:37:35.11] DAVID REDL: Jennifer, Lynna talked about this ISAM from a spectral perspective. I'm sure you have an opinion on that. But I'd also love if you could talk about as a vehicle, from the vehicle perspective.

[00:37:44.18] JENNIFER WARREN: Yeah, so we've been active in this space. Going back a couple of years, we released an on orbit docking

standard, open non-proprietary. But it's all driven by mission/use cases.

[00:37:59.83] Then we looking at my notes here because I want to remember we've also done an in-space joining experiment at the ISS, International Space Station. I know everybody knows that. So we're seeing demand signals. We're seeing mission use signals. If you like, use case signals.

[00:38:18.13] And I think one of the important things about what's happening at the FCC is it's leaning into this and trying to figure out how can it partner with industry, and whether it's meeting missions that might be coming from the government, but looking to source them on a commercial basis as a commercial service offering, or for servicing within the commercial community.

[00:38:41.20] There's a couple of things. And while we really did welcome the ISAM proceeding, and I don't want to file an ex parte. So I'm not going to look at anybody here from the FCC. We did file comments actually, that focused on a couple of key points that I'm going to bring up. Which is, how do you authorize this for maximum efficiency?

[00:39:01.38] We took the position, as did I think some others, that it ought to be authorized on an activity basis as opposed to focused on a customer. It's not the customer that's necessarily relevant. Unless for non-US customers, there may be security, export, other things that need to be taken into account.

[00:39:21.98] But it ought to be, whether it's a space tug, whether it's a refuel, whether it's, fill in the gap, fill in the blank of what that ISAM service is, be authorized for that purpose. And then look at then how do you notify the FCC so they can share with the interagency teams what the specific client is that you're going to then service.

[00:39:48.65] But you've got that general authority that you can build a business case around. It's not that each client has to make that business case for that particular moment in time. You can have a broader business model.

[00:40:02.38] And that also goes to why it's so important to understand not only who's going to authorize the spectrum, but this is an in-orbit activity, not a through orbit activity, but an in-space activity, hence the name.

[00:40:16.21] And we go back to the governance question under Article 6, who is actually exercising supervisory authority on an ongoing basis? Right now, the proposal is for the FCC to be notified or licensing it on a client by client basis.

[00:40:32.12] Again, there's no designation of the FCC as a supervisory authority. Not clear that the executive branch wants to delegate it to an independent agency or an agency that's authorized by Congress. But

these are the things that we think have to be resolved. And the FCC is going in a good track.

[00:40:56.63] I think one other thing that I would say is with respect to the spectrum, while there may be no clear ISAM allocation, there is an opportunity to take a page from the wireless industry book, which is, they do so much by identification. You don't have to recreate a category for something. So IMT, International--

[00:41:19.55] DAVID REDL: Internet Mobile Telecommunications.

[00:41:21.33] JENNIFER WARREN: Yeah, Internet Mobile. That's it. Let's just come up with our own and let's move forward. That is the easy part to solve compared to the governance and liability from an authorizing perspective. So those would be my two cents.

[00:41:36.63] DAVID REDL: Well, I'm going to follow up on that a little bit. Is there a country that's doing it right? I mean, we've talked a little bit about how, you talked about Article 6.

[00:41:42.92] JENNIFER WARREN: Not doing it wrong.

[00:41:44.25] DAVID REDL: I know. Is there a country that's doing it better, with more clarity than we are? Because we've talked a lot on many of these panels. We've talked about the fact that space governance within the United States government has 16 different venues that you have to go to get through any particular process. And so is there a model in another country that we can draw some lessons from?

[00:42:07.85] JENNIFER WARREN: Well, I would say that most other countries aren't modeled the way we are in terms of space and spectrum regulation. So I think it's really hard unless we were to go to the core of how we're structured, and we're not going to do that. I don't believe. I'm not optimistic about that. Let me put it that way.

[00:42:29.64] So working within, no, I don't think there's anybody with similar constraints that's doing it better. I do think we have a lot of groups that want to play in this. So you've got all the international organizations from the International Telecommunications Union to the UN Office of outer space affairs.

[00:42:50.58] Then you've got NGOs. You've got the Moon Village Association. You've got the Washington compact from the Hague Institute of Global Justice. You've got lots of different players that are bringing stakeholders together to talk about these issues and figure out who can come up with the best norms. And I left out the World Economic Forum. Sorry about that.

[00:43:12.77] There are more acronyms that want to participate and contribute in this space. And it's how do you harness in a world where we all have very limited resources, government and industry? We can't all be everywhere.

[00:43:27.21] And our main ask to the US government writ large, and I say our meaning a lot of space industry, not Lockheed specifically or uniquely is let's coordinate on venues, and let's decide what do we want this venue to address, and how can we use it for that. What should be here? Let's have a strategic approach to that. And I think that would help us continue to lead in space.

[00:43:53.33] DAVID REDL: Dan.

[00:43:53.96] DANIEL BAKER: I just say continuing to lead is a key point, and it's amazing how much ground we've lost in so many areas. There was a report led by Norm Augustine published in 2007, I think, "Rising Above the Gathering Storm."

[00:44:09.12] There were 48 areas of technological leadership that they thought essential. And recent analysis shows that we're behind now China or other countries. We're nowhere near lead. We were leading in those days. We're now behind in 44 of 48. Only in space areas are we still leading.

[00:44:33.09] But that's where improving governance, getting a lot of the questions we're addressing here today figure it out. And the only way to win a race is to run faster than the competition. And I fear we're running slower and slower instead of running faster and faster.

[00:44:49.48] DAVID REDL: That does assume that the competition is running the same race, which some of our adversaries may or may not be playing by the same rules.

[00:44:59.23] DANIEL BAKER: Well, OK. Well, we have to understand the rules, yeah. But no, I mean, we should be true to our own values and so forth. I agree, but there are things that we know we need to do in order to lead in space. And I think we're failing in a number of those areas.

[00:45:21.04] DAVID REDL: Lynna.

[00:45:21.63] LYNNA MCGRATH: So I'm going to take this conversation and pivot it slightly.

[00:45:25.06] DAVID REDL: Go for it.

[00:45:26.31] LYNNA MCGRATH: We keep talking about a lot of it's commercial space, and using space for economic gain. But as you also noted, space is considered a warfighting domain these days.

[00:45:37.68] We have Space Force. We're talking about doing things in a cooperative environment. What happens when this turns into a warfighting domain? So what happens when someone decides that, yeah, I'm going to go blow up somebody else's satellite because they're using that for surveillance? Now what?

[00:45:59.04] So we've got all these great things that work really well when we're dealing with commercial, and dealing with a cooperative

environment. But we have to recognize we're also dealing with an environment that very likely will turn into a warfighting domain. And what is the unintended consequences of that happening?

[00:46:19.02] And we talked about, previous panel mentioned you got national security exemptions for doing debris mitigation and that sort of thing, potentially. Well, now, we have that crossover of we've got a lot of commercial space industry is very heavily leveraged into the national security industry.

[00:46:40.74] So do commercial satellites become a warfighting target? It becomes a very interesting conversation when we change the framework that we're looking at from a cooperative. We want to get along to not turn this into a tragedy of the Commons to the fog of war. What's the fallout of that?

[00:47:04.72] And that's something I think as we work through these, it's understanding that this is also now becoming a warfighting domain. And what are the potential impacts of dealing with that.

[00:47:14.35] DANIEL BAKER: We studied the effect of a 10 megaton bomb set off in the wrong place. And we actually did that experiment a long time ago. Somebody did, the US did. We wouldn't have to worry about so many operating spacecraft in low Earth orbit if we did that.

[00:47:31.95] JENNIFER WARREN: We would still have PNT, though.

[00:47:33.81] DANIEL BAKER: Yeah.

[00:47:35.31] DAVID REDL: Yeah, right. I mean, it's both a EW problem and a kinetic problem.

[00:47:38.49] DANIEL BAKER: I know.

[00:47:38.92] DAVID REDL: Well, I mean, I think Jennifer, it's both an EW and a kinetic problem. So there's both questions.

[00:47:43.52] DANIEL BAKER: Well, the 8,000 or 12,000 communication satellites might not be operating so well.

[00:47:50.56] JENNIFER WARREN: No, yeah. Yeah, no, I'm going to sit. That's fine.

[00:47:54.71] DAVID REDL: Yeah, on that note, I will leave ample time for questions from the audience. So under the wiser rule, if there is a student that would like to ask a question first, students get to go first. Here we go. That student. You have the mic. There we go.

[00:48:18.52] STUDENT: Thank you. My name is Arvind, and I work in ITU, also, on trying to facilitate passive active spectrum sharing. So I want to go back to what Jennifer was talking about in terms of the economics and trying to quantify how passive stakeholders can actually, or giving it a monetary figure, I guess.

[00:48:36.59] So having looked into it a little bit for my own research, there are studies out there which look at, we'll tackle it as a two pronged thing. One is for Earth remote sensing.

[00:48:49.55] So with respect to weather forecast, there are retrospective studies that look to degrade a forecast and by some certain amount, by depriving an instrument from the data that's assimilated into a NWP model.

[00:49:03.89] And then they go back, and then they establish how the uncertainty tracks, say, of a hurricane, might diverge, and then what impact that has economically in terms of evacuation zones, and so on and so forth.

[00:49:15.41] So there are studies like that. And then, conversely, for radio astronomy, I guess one particular kind of application is if you use pulsar timing arrays for generating a timing reference, which can be used for various purposes for precise time references. So are those not sufficient when you said economists don't want to look into that, or are you looking for, or is the industry looking for something else that's more meaty?

[00:49:42.63] JENNIFER WARREN: So, I'm sorry. I didn't mean to cut you.

[00:49:44.70] STUDENT: No, that's it. I just want to know.

[00:49:46.73] JENNIFER WARREN: Oftentimes, there's a way to calculate the value of responsiveness from space, but not prevention. So how do you do an economic value of the prevention or the deterrence of something? Let's use national security. Maybe that's a harder one.

[00:50:06.05] How do you put an economic value on deterrence? Because how do you measure that? How do you put an economic value on the hurricane damage that didn't happen, or loss of lives and communities that didn't happen or flooding, et cetera?

[00:50:21.27] It's still a lot harder. You can put a lot of value on how quickly you were able to respond because of satellite data, than all the avoidance. Avoidance is very hard to monetize, and therefore, it's harder to convey to policymakers until it's not there anymore.

[00:50:42.65] And then, oftentimes, it's too late. And it goes back to something was said on the first panel, which is conservative assumptions isn't the way you should start. Conservative assumptions, you can relax and relax and relax. You can't roll back.

[00:50:59.66] It is very hard to claw back unless it's government sharing with government, versus government sharing with industry, because somebody will say, we paid for that under those rules, under those conditions. What are you going to give me back for clawing back

the rules or the regs? It's very naive in our litigious society to suggest that

[00:51:23.86] DAVID REDL: I'll take the moderator's prerogative and also answer the question and say, like the bottom line for passive users is that in any governance model, I don't care at what level we are talking here, international or city council, the squeakiest wheels get the grease, and passive users don't have a champion, or at least not a champion that is as economically viable, or as loud or as well-heeled as other spectrum users and--

[00:51:51.75] JENNIFER WARREN: And their associations.

[00:51:53.04] DAVID REDL: And the bottom line is that we have looked at Spectrum as a resource to create as an economic engine. And until the passive users find a way to make a better case for their uses as economic engines, they're going to suffer from the same deficit in advocacy.

[00:52:07.22] JENNIFER WARREN: AMS has been doing as good a job as possible. I think they just need more help.

[00:52:12.14] DANIEL BAKER: For that part, though.

[00:52:12.62] DAVID REDL: Yeah, other questions. Right here.

[00:52:22.07] STUDENT: So building directly on that question, I was curious about the role of the most passive actor of just everyday humans, and how everyday humans are super impacted by what happens in space, but they're not necessarily in the room for these conversations. So where do they fall in, and who is their spokesperson?

[00:52:43.40] DANIEL BAKER: David.

[00:52:46.70] DAVID REDL: I guess me. No, look, I think, and I'll speak as a former Fed, not as a moderator. But there are ways to get involved. There are ways for you to participate as an average human. I think the bottom line is with all spectrum-based services.

[00:53:02.30] I started my career working in the wireless industry, and I had a colleague that used to get asked about cell phones in the '80s when they were bag phones, and they would ask him, like, how do they work? And he'd say, they're FM.

[00:53:12.44] And they'd go, what's that mean? He goes, they're effin magic. Don't ask. It's just how it works. And that is how most Americans view spectrum-based services. It's just magic. They don't want to know how it works.

[00:53:23.49] And we all take these things for granted, and we just assume they're going to continue to inure benefit to us, that Doppler radar is going to continue to tell us where there are storm cells. That satellites in orbit are going to tell us where there's cloud cover.

[00:53:35.57] These are things we all take for granted because they're just part of our everyday lives. We don't think about how we get that data any more than we think about how it is that the mobile operators pump data into our pockets every day. We don't think about it. It just is.

[00:53:49.20] And so I think until there is a concerted effort for people to actually understand, and this is a very jaded position for me to take. But, like, until people care enough to understand how it works, they're not going to care enough until it's gone. And once it's gone, to Jennifer's point, you can't unwind that. It's really hard to take things back. Dan.

[00:54:09.65] DANIEL BAKER: Well, just from the dark and quiet skies point of view, there are many people who are now seeing in the dark regions on Earth. They're seeing satellite tracks all over the place.

[00:54:23.40] And as you say, who's speaking for Indigenous people who are trying to deal with this, pull it into their cultural viewpoint? And so it's not only spectrum, this is affecting everyone whether they know why or they know how. And I'm extremely concerned about that aspect that many people don't know what they're losing until they've lost it, and it's irreparably gone.

[00:54:55.50] JENNIFER WARREN: And too often, folks think because the apps are on the phone, space has nothing to do with it. I can't tell you how many times I've had somebody say, well, I don't need GPS, I've got this app. I'm like, mhm, mhm, we're failing. We're so failing to communicate.

[00:55:11.04] LYNNA MCGRATH: Even better, why do we need NOAA? I've got Weather Channel.

[00:55:16.26] DANIEL BAKER: That's what Congressman, no, that was Senator Russell, I think, said that in a hearing. I don't need NOAA. I've got the Weather Channel, yeah.

[00:55:24.54] JENNIFER WARREN: If I could add two things for the students. There's the International Astronautical Congress. OK, you're nodding. Great. And the International Astronautical Foundation. And those organizations offer scholarships and educational opportunities for students globally.

[00:55:45.88] So I would encourage folks who want to have their voices heard or learn how to participate or just interested in this field, future graduates from the New Hatfield professors, those are things, as well as AIAA. They all have presence here in the US, and I'm sure some of you know, but if others aren't, I would encourage you guys to look there.

[00:56:08.70] DAVID REDL: I think the other thing I would add before we chime back in is that somebody said earlier, I think it was on the first panel, you can't just say no. And unfortunately, so much of the scientific community has been saying no for so long instead of trying to

participate in the spectrum debate that they now suffer from Chicken Little syndrome.

[00:56:23.31] In policy circles, they've said no so many times, you'll destroy us. And then things have changed, and it didn't actually destroy them, that it's difficult to regain that credibility. Unfortunately, we aren't. The sky is actually falling for some of these services now. And they're finding it hard to get credibility. So other questions from the audience.

[00:56:46.83] STUDENT: I just want to make sure we didn't miss a topic that our government officials really aren't talking about as much these days, and that's climate. Apparently, it's a bad word. It's not happening.

[00:56:57.34] Climate change is not happening. That is. Well, it is. I'm speaking from an academic standpoint. I think a lot of people would agree with me, and we may, at some point, have to mitigate climate change through geoengineering. I really hope we don't. The costs are enormous. The technology isn't even there, frankly, and the science behind it is still uncertain.

[00:57:25.20] But it may be the only card we have to play at some point to avoid costs that have, I've seen estimates of many tens of trillions of dollars due to climate change that we could have avoided or may have to change someday. Now, how does this relate to spectrum? It relates to spectrum from the standpoint of being able to monitor what is happening during a geoengineering activity.

[00:57:54.87] And if you can't monitor it to within, and I won't bother to go through the basis of the number, but it's there, about a factor of 10 better more sensitive than what we now use for weather forecasting, we won't be able to have an appropriate feedback control loop that allows us to properly implement a geoengineering method. So there's a lot at stake with regard to spectrum, in particular that little bit of spectrum that's being discussed in the recent notice.

[00:58:29.86] JENNIFER WARREN: I really hope you follow comments. I'm not being flippant there. I think that's really important because so much of what we talk about in spectrum, whether it's space or any other aspect, is the today, the today incumbents activities, not looking at the growth or what's necessary for that incumbent capability, but the commercial side, the government. Look at what the government needs to evolve, its capabilities to match what's happening in the world. That's often not included in the conversation.

[00:59:03.04] DANIEL BAKER: A lot of the threats that I think we see coming are losing eyes in the sky, and not being able to see whether the policy decisions we're making, the actions we're taking are beneficial or are more harmful. Possibility of doing something that has unintended consequences are very high for what you're talking about now.

[00:59:23.50] LYNNA MCGRATH: And it's one of them, in particular, when you deal with the space science community. It's a global issue. It's one of them of it's not that the US runs all the sensors.

[00:59:37.25] DANIEL BAKER: That's right.

[00:59:37.76] LYNNA MCGRATH: That's incredibly expensive to do. We share data with all of our international partners. So the World Meteorological Organization works through, and it's their right. The US has these sensors. Europe has those sensors. Japan has some other sensors.

[00:59:54.47] When we start having these conversations, a lot of times, it's a US-focused conversation. And we don't always take into account our partner nations that we're also getting data from. And we're also pulling stuff from.

[01:00:07.70] So it may be one of them of, hey, that band there, there's no US government systems operating there. Yeah, but Japan uses that and we get that data from them, and it's hard to get that folded into those conversations.

[01:00:21.41] The FCC looks at things from a US perspective because that's their mission, that's their focus. But when it comes to space, space is very much global. And you start having these pieces of you're having an international conversation in a domestic forum, and it gets very, very challenging.

[01:00:39.19] DAVID REDL: I want to follow up and say beyond the government EESS, the Earth Exploration Satellite Service Stuff. Can any of you talk to the growth in the commercial sector, and how that's helping in this space in terms of the data sets?

[01:00:53.83] LYNNA MCGRATH: So putting on my old NASA--

[01:00:56.44] DAVID REDL: Your old NASA job might come in handy here.

[01:00:58.94] LYNNA MCGRATH: Yeah, so before coming to NTIA, I was the director of spectrum at NASA. So this is an area of passion of mine. The commercial EESS sector is a tremendous and rapidly growing portion of the space economy, and it's one of them. I don't think people saw it coming.

[01:01:15.71] And right now, our regulations really don't work well with it because most of the time the EESS bands are federal allocations. We presume that it's going to be a federal incumbent that's there.

[01:01:28.40] But there's a lot of different innovative commercial companies which are starting to do these measurements. And it's their right. How do we protect them? And when we start having these conversations, talking about repurposing, the ITU, AI 1.7, one of the bands they're targeting is EESS downlinks.

[01:01:52.04] So all right. And from a US perspective, that's a federal exclusive band. But we know that there are commercial operators there. So part of this is sometimes a bifurcated process, causes us some challenges.

[01:02:06.14] But we do have other advocates, and sometimes they don't come in through the US. They may come in through another administration where they've got better standing because of our split process, and they can come in that way. But no, that's a tremendous growing sector, and it's really exciting to see what they're doing.

[01:02:26.06] DANIEL BAKER: I think that having rather simple measurements from a lot of places is often better than having the perfect measurements from one Battlestar Galactica. And so, I think it was mentioned this morning maybe by Milo or something, that if we would work more with commercial to put simple sensors on a lot of platforms, I think we would be getting a much better picture of what's happening in our world than just hoping we'll have one, a beautiful measurement from one point in space.

[01:02:59.22] DAVID REDL: Well, we started with the challenges of dealing with commercial actors in nation state space, and I think ending on the challenges or the benefits of commercial actors working in nation state spaces is as good a place to end as any. So with that, if you all would please join me in thanking our panelists.

[01:03:13.79] [APPLAUSE]

Panel: Historical Lessons for Governing the Final Frontier

https://youtu.be/rCjKHeOtOCY?si=glVoAiHzgFRL61MC

[00:00:00.00] JP DE VRIES: All right, good. We're here. And a few people are still wandering in, but that's not a problem. Thank you very much for coming back after the break. I'm JP de Vries, Director-- my god, what is my title-- Director Emeritus and Distinguished Advisor. Please cheer.

[00:00:21.40] [LAUGHTER]

[00:00:22.21] AUDIENCE: Whoa.

[00:00:22.43] JP DE VRIES: Whoa. Woo. I had to wait so long to get a title like that. It's great. Thank you for being here. But the panel is even more distinguished by several orders of magnitude. I'm just going to start with a few words to set the scene for this panel about historical lessons for governing the final frontier, and then we'll get into the conversation. As you've been here during the course of the day, we've had all these conversations about more and more players crowding into space, the resource getting crowded.

[00:00:57.93] There are lots and lots of governance challenges, including access to resources, things like degradation of the space environment, and conflict of all sorts, both commercial and otherwise. Now, the motivating thought behind this panel is that such conflicts are not new. They come with humanity. But if we just go back, in American history, we've got-- during America's westward expansion, there were a lot of the same issues. We saw similar issues with the growth of shipping networks, managing radio interference, the growth of the internet.

[00:01:40.57] And so in each case, what happened was that the rules and the norms that were set early on shaped the long-term outcome. And so this panel, what we're trying to get a handle on is, what can historical experiences, both going back to the opening of the West in America and also more recently, teach us about space as humanity expands into space? So, what would space governance look like, is the question, if we take history seriously.

[00:02:15.19] So I'm going to keep the introductions very short, the way we do here at Flatirons, because you can go online and read the illustrious bios. Each of the brief descriptions I will give are just teasers. We have Jennifer Manner, who is a regulatory spectrum and policy expert with deep experience in industry and governance. And anybody who knows Jennifer knows that that just scratches the surface. So go read more.

[00:02:44.62] Same for Carolyn. She's a distinguished-- or this Distinguished Chief Spectrum Economist at The MITRE Corporation. Suraj Jog is a technologist and senior research scientist at Microsoft Research. And last but not least, by any means Patty Limerick, Patricia Nelson Limerick, professor of history of the American West and also director of the Applied History Initiative here at CU, Boulder.

[00:03:16.49] So I'll tee up each of the panelists with a question, and we'll get into a discussion. The panelists will respond to each other. We'll see where the conversation goes. I'll ask folks to join in from the audience, depending on time. I will impose the wiser rule, but it'll be the original wiser rule, which is not that students get the option to ask the first question, Students are required to ask the first question.

[00:03:48.83] And if there aren't volunteers, I will volunteer somebody or I will ask faculty to volunteer somebody. And the last thing and I will remind folks again when we start, please, when you ask a question, identify yourself by name and affiliation. Even if you've done so earlier today, please do it again. Because somebody might be watching this online for the first time, and it's helpful for them to know where your questions are coming from.

[00:04:15.48] So to kick off, Jennifer, how should we think about space sustainability? What's the best framework or mental model?

[00:04:24.91] JENNIFER A. MANNER: So first off, thank you for having me, and thanks to Silicon Flatirons. I want to say I'm thrilled to be here for the Hatfield announcement today, which I think is fantastic. And I hope everyone went to the QR code and donated additional money. You can see I've done fundraising before.

[00:04:40.99] JP DE VRIES: [CHUCKLES]

[00:04:42.34] JENNIFER A. MANNER: So this is something I've struggled with, because the reason I got into communications and satellite communications is because of my real interest in, how do you allocate scarce resources? And so I was originally going to be an admiralty lawyer, but it was a dead field by the time I got out of law school. So really thinking about where do we look at places with similar challenges.

[00:05:05.07] And I picked two in particular, maritime law and airspace management, I'd call it. And if you look at the law of the sea, it was established to have international agreements for a number of things-- to prevent overfishing, to prevent pollution, to prevent territorial disputes. And what that's resulted in is largely not perfect-- I can find lots of instances where it's not perfect-- but orderly, sustainable use of ocean resources, understanding there's a shared responsibility, and a need for international cooperation.

[00:05:37.74] Similarly, when we look at the management of airspace, which I think works remarkably well, you have coordinated efforts

under international treaties, Chicago Convention, and so forth to ensure that flight safety and environmental considerations are balancing. So if you think about space, I would argue that there's also a need for a comprehensive framework that encourages responsible behavior. So for things like preventing space debris or minimizing it, managing satellite congestion, allowing the use of space for scientific missions.

[00:06:09.25] We have treaties that cover Antarctica, for instance. How do we avoid conflicts? And I think that if we don't start moving more and more in this direction, we're going to have a number of failures. Now, we have some basic space treaties. We have the Outer Space Treaty of 1964. We have other things. These are insufficient, in my view. You can't rely on what's there. It wasn't built for the same thing. And I was having-- I'm looking for Jillian.

[00:06:39.33] I was talking to someone last night who actually brought up an interesting-- she's in the back-- an interesting point that the treaties, the outer space treaties and so forth, were done really before humans were going into space. So there's also that consideration. So I'd argue that even more importantly than treaties or rules or something is that you've got to have best practices. And they have to be technology neutral.

[00:07:04.93] I think the one thing we've learned through other things, whether it's the ITU radio regulations, whether it's the law of the seas, areas that we need to have evolution in technology-- and especially in this day and age, it's so fast-- but these best practices have to be developed. And they have to be implemented. So we can think about things that are-- designing satellites that are more durable, capable of de-orbiting safely, minimum debris-- clear guidelines for responsible satellite deployment and operation.

[00:07:34.45] Transparency, I think, is critical and collaboration. And that's one of the areas that I think we've had a lot of problems with. But sharing data about space traffic and risks. Some of these are not just important for safety, they're important for economic reasons. They're important for long-term viability of space and socioeconomic development of countries. So we need to really make sure that space-based operators and governments and companies, academics, anyone in space, has the mindset to be a steward of the environment.

[00:08:16.19] And I was going to give you an example. I'm at a company called AST in science, or AST SpaceMobile. You may have heard us. We're building very large antennas. 24 meters, so the size of tennis courts. And one of the things I learned the moment I walked in the door was that my CEO cared about this. And he made sure that the satellites that we're putting up are fully demisable. So they'll go through the atmosphere and they'll burn up. We can argue whether there's atmospheric issues and so forth.

[00:08:44.03] But part of good stewardship, another thing was they went forward and did a very early agreement for the company with the National Science Foundation. I think Ashley's in the room. So going forward and taking that mindset as a company that not only do I want to make money, but I want to make sure that what's in the long term is good for everyone. So you'll see this. And I can name other companies who've done similar. And so you've really got to have this joint stewardship no matter what, even if you can't get together and do treaties.

[00:09:15.99] And I've heard arguments, can you do a new treaty? Some people say yes. Some people say no. It's the times. But I think at a minimum, getting those best practices, working in areas and groups like the ITU where there is work being done on a space sustainability handbook, UN COPUOS, which is talking about these very same--

[00:09:34.82] JP DE VRIES: Acronym?

[00:09:35.16] JENNIFER A. MANNER: Oh, Committee on Peaceful Uses of Outer Space. Jodi's shaking her head, so I know I got it right-- and groups like this where you can work together. So even where there's not treaties, working together, making sure trade associations are focused on it, and bringing it as far forward as you can. And then companies and governments also working responsibly, because governments still put a fair amount of effort in space. So thank you.

[00:10:00.19] JP DE VRIES: Fantastic. I have lots of follow-up questions I'd like to ask, and I'm sure you do too. But we'll get to that. So turning to Carolyn-- actually, it occurs to me that homework should be, ask your friendly AI to come up with a punch line. A lawyer, an economist, the scientist, and historian walk into a bar. [CHUCKLES] Carolyn, our economist. So when I think about the economics, there are just so many questions that come up. But the immediate one is, so people talk about a scarce resource, as Jennifer did. Do you think about space that way? And if so, what's scarce?

[00:10:41.73] CAROLYN KAHN: Sure yeah. I mean, economics, I think, is vitally important to our society and to technology and to law. And allocation of scarce resources is economics at its core. It's not just making money. It's how to pay for things, how to prioritize. So in space, I mean, we've got orbital slots that are scarce. There's only so many of them. Some are better than others. And so, how do we allocate that as a scarce resource?

[00:11:18.93] Is it first come, first serve, which is often done? Is there equitable access? Who's going to pay the most? Or which one has the most economic benefit which is calculable but difficult to calculate, as Jennifer Warren was talking to you about in the last panel. So how best to allocate these scarce resources. Also in space, electromagnetic spectrum is a scarce resource in terms of bands that are available and

that are effective and where the physics lines up with the needs of space.

[00:11:57.97] With the attenuation in space, more objects in space, more wireless communications-- so requiring more spectrum. So we've got interference-- so how best also to allocate use of spectrum and access to spectrum? Also, we have asteroids and natural resources. And again, how to split that up. Is it extraction? What is the best way to do that? And then physical space. For instance, on the Space Station-- in rockets, there's only so much space. So how to optimize that, how to prioritize it.

[00:12:44.95] And so these are tough questions. And not only is it difficult-- probably in this room we have different perspectives, I'm sure. In our country we have different perspectives-- but then, there's so many challenges with space in terms of cost, distance and so-- and differences of opinions across countries. Because space is very global, as was talked about.

[00:13:10.24] And so what is the best way to do that with all the different opinions that are out there and with how things have been done so far? But I do think that these are vitally important questions. And we need to make progress. And the more progress that we make, the better the resources will be allocated so that they can be used as best as possible for our world.

[00:13:34.23] JP DE VRIES: Just a quick follow-up. I mean, one of the-- I'll be the second one to check this point about the economist. You get the second last word. But when you talk about all those trade-offs, when you think about all those trade-offs, what's the role, if you think back to previous cases that you've seen and worked on, of economic analysis versus engineering analysis?

[00:13:58.28] CAROLYN KAHN: Oh, wow. Great question. I think I ask these questions and come across these questions on a daily basis because I'm at a systems engineering company. And so, I mean, technologies, I mean, that's how-- you need the technology for innovation, to build the science. I mean, that's how you innovate. But it's expensive. [CHUCKLES SOFLTY] And so you can't do it without prioritizing and coming up with a way-- how is it those costs can be paid for, over what period of time, and how to prioritize it over other-- other trade-offs, other needs that are also important. And what's more important? Maybe what's the low-hanging fruit? What can be done? What doesn't cost much money? But yeah, these are essential questions. And where decisions are made all the time, are they the best decisions? Probably not all the time, maybe, but I think in the moment people do try to make the best decision for each specific case.

[00:15:04.05] JP DE VRIES: Great, thank you. So turning to Suraj. I mean, Suraj, you actually have a very interesting background because

you're out there innovating, creating new solutions. And one of the things I know you've worked on is using unlicensed spectrum for IoT satellites, which is not something we've heard about much yet today. So when you think about that and using opportunistic, unlicensed spectrum for satellite services, and when you think back of other things that you hear people talk about like CBRS and TV white space, how do you think it compares? What's different? What's the same?

[00:15:37.88] SURAJ JOG: Great. Well, "the need for spectrum is always increasing" is a constant statement you keep hearing when you do wireless research. And so given the limitation of spectrum and the fact that so much of it is already licensed out and very little remains unlicensed, there have been multiple efforts recently, where they talk about, hey, this spectrum is technically licensed, but it is vacant for most of the time or for a significant portion of the time in certain areas.

[00:16:08.98] So can you have a scheme where you can dynamically access these portions of the spectrum while it's not being used by the incumbent users? I think there was some mention of this in the earlier panels today as well. I mean, the first effort that I remember happening in this space was something on the TV white spaces, which, actually, I think, came out from my group, but back when I was in the fifth grade. So--

[00:16:35.04] [LAUGHTER]

[00:16:35.98] So I had nothing to do with it then. But the idea is that in these rural areas, you have this TV broadcast spectrum that pretty much remains vacant. So the idea was, can you identify gaps in the spectrum, which they called white spaces, and opportunistically transmit on the spectrum with the condition that incumbent users are not affected? So whoever paid for the spectrum, still we meet their certain guarantees as prescribed.

[00:17:06.07] This kind of did not really take off. I mean, we used it a lot for one of our projects that was agriculture based, where digital agriculture, we could aggregate sensor data to the farmers. But beyond this, it didn't really take off. And I think one of the primary challenges there was the lack of unified or consistent spectrum across just this country, just the US, right? The TV spectrum goes from around-- UHF and VHF-- it goes to from 50 megahertz to around 700 megahertz.

[00:17:38.33] And something that's available in, let's say, the Pacific Northwest is not going to work in LA. And as a result, vendor adoption was very limited. And this never really saw widespread adoption. A more recent effort, CBRS, which allocates spectrum in the 3.5 gigahertz band-- kind of rooted in the same philosophy that something is allocated. I believe CBRS, 3.5 is for military and navigation purposes.

[00:18:06.16] But the idea there is at the 3.5 gigahertz, again, they'll do the same sort of model of dynamic spectrum sharing and will allow

general, authen-- general users to access it if vacant. The one thing that worked well for CBRS was they got around this big issue of TV white spaces with the fragmented spectrum, where they focused on this band from 3.5 to 3.7 gigahertz, and they tightly controlled who accessed it, who did not. And it was uniform across the country.

[00:18:37.01] Although it's still debatable whether it's as successful as it was envisioned to be. But at least in terms of vendor adoption, for instance, you can see it a lot more widespread. In fact, I believe Android supports CBRS band 48, I think. So, given this-- moving on to the satellite context-- the problem of satellite is very different, right? Terrestrial radios are confined to a country. Satellites potentially have exposure to all countries around the world.

[00:19:07.02] So if there is no consistency in terms of what spectrum is allocated, in which countries, then, again, we run into the same issue where either you need to have more sophisticated satellites that can do channel switching as it goes from different geographical regions, which, again, means the coordination overhead increases, the satellite hardware gets more expensive, and, in turn, could lead to the same issues that TV white space faced. So I think one of the primary-- one thing that really helped with keeping this cost-efficient is the consistency of, what spectrum do you want to use for this application across the globe?

[00:19:43.81] JP DE VRIES: Great, thank you very much. Perfect. So our last person in the first round is Patty. And I was going to ask and I will ask her this question. And the reason she's going last is she's the person who listens to all the people who know about space and spectrum and says, well, this is what we can learn. But the first thing was, she has got a little comfort blanket for the astronomers.

[00:20:13.29] PATTY LIMERICK: I do.

[00:20:14.12] JP DE VRIES: Go ahead, Patty.

[00:20:15.27] PATTY LIMERICK: Oh, thank you. Really fortunate surname, Limerick. Really taken with what I had read beforehand, which-- it was about the dilemmas of the astronomers. Astrophysicists recognized I couldn't do a damn thing for them. So that was a little bit frustrating. But then I thought, I could write a limerick for you. So this should be a great comfort to you. OK.

[00:20:36.07] [LAUGHTER]

[00:20:37.53] If we could only master the grace to respect the wonders of space. Astronomers grow sad when their signals go bad. And they fear that they're losing this race.

[00:20:48.97] [LAUGHTER, APPLAUSE]

[00:20:54.87] Then there are two other limericks, but we'll hold those for a moment. So humorously-- as if I ever do anything else, I guess--

but I was here two weeks ago for the conference on the crisis of the Colorado River. You want to talk about scarcity, scarce resources? We should have had you there, Carolyn, because good lord, what questions and choices about scarcity. So I feel like, in some ways, I was kind of training for that.

[00:21:18.34] And that really makes the point here about how comparing-- so I'm perfectly at peace with this, Jennifer. You scooped me. I was going to say, you know, maritime history. Terrestrial and maritime relations, terrestrial and space-- boy, is that waiting to freshen our minds and make us think. And then you got there first. So it's in my notes here, but I had--

[00:21:40.24] But I just think that is a wonderful way to get ideas that have become predictable for us and familiar, to freshen them up by thinking, well, then let's just think about where those two forms of, really, a basic arrangement of matter, where they intersect. And why don't we think, for instance, about the Northern Cheyenne people, who innovated tremendously by making a case that succeeded in the courts that their reservation extended into the air, that the air shed was their-- was part of the reservation?

[00:22:11.51] So, my goodness, there's just so many ways to say-- we really get our minds moving when we move our attention from one zone to another. Interesting that I was here for the struggle with scarcity, the others. And then it seems to me very interesting that everyone has used-- not everyone, half of everyone, which is painful to think about-- but half of the crowd has used the word "frontier." And it is everywhere in our titles. Our session is referred to as frontier. So that's pretty funny.

[00:22:44.58] Because in 1986, the Paine Commission-- the report of the National Commission on Space came out. And you'll notice it's kind of a lurid cover. You can see that. All you're supposed to see is the pink and purple and so on. So that came out. And it is full of confessions of ignorance of Western American expansion. The goals are almost breathtaking, as they lay out a confession of ignorance.

[00:23:12.45] So I'll just read one of them to give you a sense of-- oh, my goodness. OK, ready? OK, this is our purpose. Free societies and new worlds. The settlement of North America and other continents was a prelude to humanity's greatest challenge, or greater challenge, the space frontier. So here, you have that direct-- westward expansion, space. And you have an old-fashioned version there, that North America was kind of empty and then settlement occurred. So, OK.

[00:23:46.55] As we develop new lands of opportunity for ourselves and our descendants, we must carry with us the guarantees expressed in our bill of rights to think, communicate, and live in freedom. We must stimulate individual initiative and free enterprise. And so we are

going to bring to the alien life forms-- we're going to bring to the alien life forms what Columbus and the settlers brought to the Indians.

[00:24:14.97] [LAUGHTER]

[00:24:18.02] Well, how quickly can we warn the Navajo? I mean, it's really-- it's beyond understanding how this could have happened. I don't need to read any more of it. But it did stir me up. And it did make me think of-- it's kind of interesting that the pages seem to have been torn from the book, and I did not do that on purpose. And I didn't do it at all. But anyway, this was my chance to say, here is an enterprise that is not-- that's using the language-- frontier, Wild West-- using that all the time, and showing not the slightest curiosity about what they're referring to.

[00:24:51.46] So that led to my running into Phil Weiser in the grocery store, where we just ran into each other in the grocery store. And I said, at Silicon Flatirons, if you are forever with people who say "frontier and Wild West," you'd think you'd want a Western historian there, but I guess not. And I started to move on to the celery. And he said, well, why don't we try that? Because that would be Phil Weiser. So this is my 10th or 11th visit here to Silicon Flatirons. Whether that's a good idea, we'll find out a little bit more here.

[00:25:20.16] But it is a frequently used word in this-- "frontier" is frequently used in this context. It's tempting to go straight at it in mockery and to say, oh, perhaps you're thinking of the transcontinental railroad as a great enterprise. Perhaps you're thinking of that. That was an enormous frontier achievement. It went so fast. They did that so fast. They did the transcontinental telegraph even faster.

[00:25:46.42] So we could do that. One thing you can do with applied history is you can tell inspirational tales. And you can configure that, I think rightly, into an inspirational tale. They really went to town. They got that thing built. OK. Applied history also tells cautionary tales. OK. It's almost a checklist of, oh, please, space people. Oh, watch out for this. Federal partnerships with private enterprise-- astounding levels of corruption with the transcontinental railroad.

[00:26:17.89] Structures built so fast that they had to be rebuilt a few years-- well, a few months later. Complete indifference to the experience of human beings. The construction manager for the Sierra said they never had a count of how many Chinese people died. They could get more. OK, so when I and my colleagues hear President Obama say that renewable energy will be to us what the transcontinental railroad was to the Americans, I think-- in the 19th century, I think, don't say that about us.

[00:26:48.86] We don't do that. That is just rude to say that. Ronald Reagan did the same thing. It's bipartisan. People who are going to use that frontier metaphor, they don't-- they're from all-- there are parties that haven't even been invented yet. OK, so we can say

cautionary tales, inspirational tales, and the best kinds of things historians can offer, hybrid tales, cautionary and inspirational. And I would say the transcontinental railroad is that, it is astounding. We have been-- for 30 however many years, I've lived in Boulder, Colorado. We've been talking about getting a light rail from Boulder to Denver.

[00:27:21.61] [LAUGHTER]

[00:27:23.96] Still checking. We're still checking. So I don't want to say, let's take the inspiration out of the achievements. Took on incredibly tough things and often prevailed. So I don't want to say that. But I want to say, let's take advantage of an anniversary. Because you may have noticed that Americans pay no attention to history much of the time, but they will wake up for-- and I don't mean woke-- they will wake up for an anniversary. So, 40th anniversary next year of the Paine Commission report. Good, round number. They projected 50 years into the future.

[00:27:59.73] JP DE VRIES: That's great.

[00:28:00.50] PATTY LIMERICK: Time to get started. Time to get started on that. So that is my framework. And then I just want to give one practical example of what you can do with applied history when you really get-- doing something meaningful. Engineers are crucial in Western American history. They're far more important in lots of ways-- and I want to say this in front of some groups, but engineers are far more important than cowboys in Western history. OK, we'll say that somewhat, it is.

[00:28:21.12] But something has gone wrong, and was probably going wrong back then, in the relationship between engineers and society. Over a century or so, engineers did an astounding amount of things to get the American people resources that they wanted and they wanted fast and they wanted-- when they wanted it. So unfortunately, consumers pay very little attention to production.

[00:28:45.72] So very soon, after this pattern was in place and engineers were getting American citizens what they wanted, the relationship had gone-- had developed potential for a really unproductive friction. So by the mid 20th century, certainly by the late 20th century-- this is another limerick. While we would never want to be catty, engineers have made nature ratty. While they fill all our needs, we bombard them with screeds, which, for some reason, drives them all batty.

[00:29:12.93] So, better relationship, new relationship. That's one lesson of Western American history, is think that through and renegotiate the relationship between engineers. That is both inspirational and cautionary and hybrid. And now two last limericks. And I'm taking up too much time, but that--

[00:29:27.01] JP DE VRIES: Yeah, you--

[00:29:27.48] PATTY LIMERICK: It's where you're having to think.

[00:29:28.14] JP DE VRIES: We can always come back with-- we've got--

[00:29:30.06] PATTY LIMERICK: Because they're so fast. They're really fast.

[00:29:31.48] JP DE VRIES: OK.

[00:29:31.78] PATTY LIMERICK: This is the picture--

[00:29:32.89] JP DE VRIES: Don't rush. Don't rush.

[00:29:34.09] PATTY LIMERICK: OK. Well, our big picture from what we have heard today, our hopes are darkened and shrouded. And our-- excuse me. Our hopes are darkened and shrouded, and our views have turned dark and clouded. When we look at the sky without-- OK, excuse me-- can we look at-- oh, I'm so sorry. This is too fresh here.

[00:29:55.59] When we look at the sky, we want-- gosh, for me to say-- when we look at the sky, we find ourselves wanting to cry since we've learned that space is now crowded. OK, so that-- so you can see that actually rained really well. Our hopes are dead and shrouded and so on and crowded, so it's really quite and crowded.

[00:30:16.71] And then as to the word "frontier," it is never useful to jeer at the love for the word frontier, but we should not spurn our chances to learn. With learn, what lies just beneath that veneer. Those are my words. I'm so sorry. Thank you.

[00:30:33.68] JP DE VRIES: So, for those of you who want to learn more about what's beneath the veneer, Patty wrote a paper in 1992. And if you want the reference, either look it up or just come and ask me and I'll give you the reference. In fact, Dale told me that this was one of his early exposures to this whole question of space, where she analyzed the obsession that the space community had with the frontier and all the ways in which that was perhaps a dangerous and ill-advised analogy.

[00:31:04.80] So let's go back-- what I'd like to do is to have each of the panelists, again, in order just to respond, make further comments, pick up where they left off. Given what you've just heard, what comes to mind for you in terms of lessons that we should learn and apply to space? Jennifer.

[00:31:22.29] JENNIFER A. MANNER: So I wanted to come back to Patty's comment about the Navajos, who I guess sued and got air space.

[00:31:29.30] PATTY LIMERICK: It was the Northern Cheyenne.

[00:31:31.19] JENNIFER A. MANNER: Cheyenne, yeah. So we did have this issue years ago. And I don't know how many of you have heard. I know at least one person has of Tongasat. And Tonga years ago claimed all the orbital slots above their country for geostationary. Orbit satellites are around the equator. And so basically, that gives you really good coverage.

[00:31:53.82] And so that was actually a big issue was, could countries claim that they own that? And that was a determined that you can't do that. It's the province of mankind. That's what the Outer Space Treaty says.

[00:32:06.27] JP DE VRIES: Who determined it? Who was the judge?

[00:32:08.73] JENNIFER A. MANNER: There is no judge. It was ultimately-- that I can think of, I'm looking at Jodi. There's no judge. Do you remember? It was just-- it was the rest of the world, it went to the-- it probably went to the--

[00:32:19.43] JP DE VRIES: Everybody else just laughed?

[00:32:20.88] PATTY LIMERICK: Well, it just became a point. I mean, they literally said we control it. And basically, the ITU, which manages the resource took the position that no, you don't. And there's enough-- so the way-- let me back up. And I think this is really important. And this is why I talk about best practices. And even without a treaty, and I personally do think we'd be better off with a treaty on space sustainability.

[00:32:45.65] Pressure matters. And one of the great ways the ITU works is through political pressure. And countries are really forced because you have a whole bunch of countries all swimming the right way. If you have someone who's going against you, you're going to end up with interference.

[00:33:01.58] And so the whole purpose of the ITU was formed actually, one of the reasons was after the Titanic. Part of the reason why Titanic had had trouble getting people to save them is they couldn't make a call that was-- that sounds really funny. I'm getting a feedback.

[00:33:15.60] But there was interference on all the channels so no one could call out. And that was one, among other reasons that they went forward and started the International Telecommunications Union. So where you've got issues, you're going to run into one another. You're going to cause interference. You're going to cause other harms.

[00:33:35.04] Countries will hopefully act in the right way. There's enough political pressure. Now things that limit that are money. And I'd say money is always an issue, doing certain fixes are expensive. And to sovereignty, countries very much want to control what they do. And that's whether it's a big developed country or a small country. So you've got those pressures. But in the long run, I think trying to leverage, certain basic requirements will help to improve this.

[00:34:07.75] JP DE VRIES: I mean, this is a question for you and for Carolyn, for everybody. And it's one of the Dale Hatfield Memorial questions or obligatory questions. We have the Weiser rule. We have the Hatfield questions. What are the incentives that are going to make people exert pressure? What are the incentives that are going to drive people to collaborate? We had calls for that in earlier panels.

[00:34:32.11] So why should countries collaborate?

[00:34:35.44] JENNIFER A. MANNER: I'll answer that question. Probably safety is number one. Safety, protection, and whether that's for-- we talked about Gillian had brought up, at the time all this was, there wasn't a lot of people. So you're going to have humans in space. And every time there's a problem with the Space Station, we hear, oh, my God, they had to make maneuvers, right?

[00:34:53.02] JP DE VRIES: Yeah.

[00:34:53.19] PATTY LIMERICK: So as more people go into space, but safety of crafts, I mean, it's a financial issue. I spend money on these things. I want to make sure that I can get them into space and operate properly.

[00:35:05.86] CAROLYN KAHN: With your opening remarks. When you're talking about the air traffic management system, what I was thinking at the time is because safety is so important, I think people are incentivized for that to work so well. I also think things that are important, so if it's so important, it needs to be so important to all the different countries in terms of safety, in terms of priorities, to work together and find out what are the basics that different countries will agree to incentivize towards working together and toward meeting what you're trying to achieve.

[00:35:45.70] Unfortunately, I think one incentive and, Jennifer, you mentioned this earlier is when there's a catastrophe, because then I do think that explodes in the news and brings people's attention, it makes funding more of a priority. Politically, it becomes more of a priority. So that's not really-- a proactive incentive would be much better. And so I think proactive incentives to work together toward what we need would be more productive to avoid--

[00:36:16.99] JP DE VRIES: What is a proactive incentive?

[00:36:19.24] CAROLYN KAHN: To drive people towards the right behavior and towards the right-- doing the right thing versus after, to avoid a--

[00:36:26.80] JENNIFER A. MANNER: I was thinking the Artemis Accords. So the Artemis Accords, which I haven't had much experience with, but they were started a number of years ago when Scott Base back in Trump 1, when Scott Base was at the White House and the idea was to create an agreement on lunar exploration and so forth.

[00:36:45.29] And so a number of countries, I lost count of the number, I'm sure it's over 50 by now, have signed up to these Accords, and how we're going to share resources on the moon, I believe. It was largely lunar. But it was successful. I was very disappointed in the accords, mostly because they didn't talk about space sustainability. I thought they lost an opportunity, but it's still been a very successful accord system to come out with certain standards, certain practices on how to operate in lunar. And I said, I'm not the expert on it. So I don't know, Carolyn, if you know more about the Artemis Accords than I do.

[00:37:21.20] CAROLYN KAHN: I'm not, but I think it's a step in the right direction. Yeah.

[00:37:24.32] JP DE VRIES: Suraj.

[00:37:25.97] SURAJ JOG: Yeah. So adding on to the point, in terms of the finances of what is the incentive for adding pressure, it's not just about-- I think in addition to making sure you can reap benefits of what you've invested in it, I think cooperation also helps bring down the overall cost of getting it operational in the first place. Because, again, as I mentioned in the previous example, having consistency across spectrum usage automatically makes your hardware cheaper, because you don't need multiple RF chains and so on.

[00:37:57.50] There is another point that I want to touch upon. So in a lot of these panels today, we've been talking about how we want to avoid interference when it comes to the usage of this wireless spectrum. I have a slightly right field thought, where why not embrace the interference?

[00:38:16.75] So what happens is when you slice out a chunk of the spectrum exclusively for one user, if that user is not using this all the time, then your capacity is wasted, your channel is wasted. What you could do instead is let people interfere and remove the complexity from the coordination of the protocol, and bring the complexity into the signal processing part of it.

[00:38:38.00] So I let people interfere. But by using better signal processing and wireless techniques, I will make sure to decouple this interference at the ground station and still be able to provide accurate reception for each user, even though technically they have collided on the channel. And I think this is-- I mean, of course, it's a governance nightmare. I speak just as a technologist, so the fact that it works on a computer is good enough for me.

[00:39:02.07] So I'm sure like my approach is probably very naive. But this is a thought that I want to throw in there, that why not just let-- of course, not the whole spectrum, but why not embrace a bit more of interference is OK. But at the application layer, I'll make sure to separate it out and give you the correct packet.

[00:39:22.83] The other reason why this will work very well in the space context, and not necessarily in the terrestrial context, is because the footprint of satellites on the Earth's surface is huge. So you can leverage something called spatial diversity, which is this idea that, hey, there is one location on the Earth that has very poor reception, but another has great reception. So you can combine packets received at different locations to be able to get better throughput in general.

[00:39:49.42] PATTY LIMERICK: I would like to ask the question, I think it was Jennifer Warren was remarking on how we, millions of us are benefiting from a service that we're not paying for, which is very interesting. And speaking of production and consumption gaps. That was very striking.

[00:40:07.37] So I'm wondering if there is something about public relations. And I don't mean that in a light way, but that we should know that we are getting a service we're not paying for. And companies should organize their behavior to have the public like them.

[00:40:26.21] JP DE VRIES: So are there any-- when you think back-- and again, this is a question for all of you. When you think about your experience with other cases, are there places where that worked?

[00:40:37.73] PATTY LIMERICK: Yeah.

[00:40:38.32] JP DE VRIES: Give us an example. Give us an inspiring example.

[00:40:40.10] PATTY LIMERICK: And I don't think I'm saying do put more money into the public relations unit of your company, don't do that. But that could be really where the action is if it's done well and done with integrity and the rebuilding of trust, that seems like a--

[00:40:54.59] JP DE VRIES: I suppose, as an immigrant who didn't learn this history at school, when I think of public relations in the American West, I think of leaflets going to Eastern Europe saying, hey, it's like, the rain follows the plow. This is going to be amazing. Just move West. There's nobody there. That didn't work out.

[00:41:14.33] PATTY LIMERICK: Very quickly, the Progressive Era when we were boys and girls in graduate school. And we researched that almost always when Theodore Roosevelt was out denouncing industry and robber barons, there were private communications with industry and robber barons, saying, would you please regulate us so that people will not fear and hate us? Would you please do that? So that's not in public record particularly, but it is boys and girls in graduate school. I think we all found that pattern.

[00:41:39.26] JENNIFER A. MANNER: So we did the space industry did do some-- has done things. It's the-- Society of Satellite Professionals has put out a day in the life of satellite, a day in the life without satellite.

[00:41:52.02] JP DE VRIES: Yes.

[00:41:52.31] JENNIFER A. MANNER: I mean, so there are things it's just at the end of the day, this isn't-- unless there was a huge groundswell of support and what Jennifer-- my fellow Jennifer-- can never have too many Jennifers, was talking about was GPS, which we all benefit from. Every single person here has GPS chips on them today, but most people don't think about it.

[00:42:12.53] But it's how do you get the decision makers, at the countries and at the companies to care. And that's a harder thing to do. And I think it's one of the issues that the space industry has had throughout my career is, it's you don't see it, so you don't think about it. And I think someone said earlier, no one thinks about spectrum. No one thinks about space. So you're getting service from space. Maybe you think about it for five seconds at some point in your lifetime, but most people aren't.

[00:42:41.75] But I'm not sure that would take-- that would change things because it's just not enough focus. But certainly, there's been attempts and mind you, not terribly successful attempts.

[00:42:52.98] I mean, one of the things and I think this is something you mentioned at one point, Patty, that this question regulate me, please, where you have a bunch of players and in space, where there are lots of sovereigns, there's no arbiter. Why would people come to agreements? And I think one example that you mentioned was mining claims, where-- so tell the story of mining claims.

[00:43:19.62] PATTY LIMERICK: Thank you. Personally, I have not written a Limerick that I'll stumble over so I can just do that. So when miners went to California, there was nothing in legal authority there. There were no treaties giving them access. The soldiers, there was military there, but the soldiers mostly deserted and went to the mines. So it was very disordered.

[00:43:38.17] So if you wanted to see things go really poorly in terms of people wanting to resource and piling on to it, this would be the place. But pretty soon, it became clear that you really did not have a resource if you didn't get that resource respected. So if you made a claim and there was no order, then your claim was gone. As soon as you went took a nap, your claim was gone.

[00:44:00.82] So what do you do? You have to say to the people around you who are your rivals, who you would so prefer to outperform and riches, you have to say, could we get a system here? If I don't steal your claim, could we have a peace-- well, and it comes-- people can come together. They don't do it one on one. They come together and say, this can't go on this way. We're all losers.

[00:44:25.63] And there's been some romanticizing of that, that that some inherent Anglo-Saxon trait to say, we've got a problem and we must find a way to be in solidarity. That's nonsense. That's just people trying to say, if I don't pay attention to what you're doing and respect

that, I lose everything I was trying to get to. So that's probably the best example, but I could-- well, there are others, so just--

[00:44:49.00] There's a reason to confine my ambition a bit, not surrender it. But if I want that ambition to deliver, I had better get some pals working with me. And so that's when a lot of what I hear here, I think. At some point, maybe they're not going out for dinner enough. Maybe it's--

[00:45:09.59] JP DE VRIES: Well, that's what occurred to me. I mean, you folks who are going to the world radio conference and all these kinds of things, it seems like where people know each other and trust each other enough, stuff like this can be resolved. Do we need new venues? Do we need to send people to certain existing venues more often? Are there cases in the history where venues have gone bad? Sure, yeah? Go ahead, Carolyn.

[00:45:39.81] CAROLYN KAHN: I mean, good questions, like the in-person dialogue and knowing someone versus something that's not personal at all and how-- our negotiations, I assume, they are better when they're in person and when you know the other person and you have empathy and you can share. It's not just the information but kind of backgrounds, why different perspectives are important, and come up with a better solution overall.

[00:46:06.56] JENNIFER A. MANNER: But I would argue maybe we have the wrong venues. So the ITU's jurisdiction, and people can argue whether it is as my view is more constrained. It's not focused on space sustainability for our sector's focus on spectrum and orbits and managing it for communications.

[00:46:23.01] This is a much bigger issue. We're talking about space generally, whether it's interplanetary, whether it's mining on the moon, whether it's ISMs we talked about earlier, whatever it is. And that group, I think the ITU has been very successful. But because it also includes industry, non-government actors quite openly, not in decision-making roles, but in participation, active participation, and his governments, then you have the COPUOS, the Committee On Peaceful Uses of Outer Space, which is largely limited to governments.

[00:46:57.63] It's a very different agency. It doesn't have treaty-making authority. There's limited participation by private sector or non-commercial, non-government members. And also, while it has a bigger jurisdiction, so right now, you don't really have and I don't see much will on the part of governments to extend that.

[00:47:18.72] Remember, space is a very important area. Everyone wants to be first in space since the time of space travel being created, whatever. When inter-Sputnik, before Sputnik was-- everyone wants to be first. And every government you hear speak about it, whether it's Africa or whatever, they want their own piece of it. So you've got that to work about. So I don't see the political will to solve that problem.

[00:47:42.90] So having the people at the ITU talk about space sustainability in my view is really nice and it's interesting. But we're probably not the right people. We're not the people who are dealing with the day-to-day issues. And COPUOS is a better forum, but they don't have the right people, enough of the right people, and they don't have any ability to take decisions. But I don't see the political will for anything more at this point, for better or worse.

[00:48:07.92] CAROLYN KAHN: I mean, it seems like something is needed more, probably more in the existing forums, maybe an additional framework or getting, like you said, the right people involved, and having things done at the pace that's needed because interest in space is not slowing down. So this is definitely something that's needed. And I think the multidisciplinary skills, people need to come together and make progress.

[00:48:33.43] JP DE VRIES: I mean, this is, clearly, this area is becoming more and more commercial. And actually, I'm trying to ask two questions at once. One of them is, every time you say [NON-ENGLISH SPEECH], my eyes light up because it just sounds so cool.

[00:48:47.30] But I imagine that the UN Convention on the Law of the Sea, it was actually earlier laws of the sea. It was contested. There were people who had commercial rights. And so my question and again, maybe in the American West or other experiences you've had, where it's not the governments and the states that get together, but it's actually the commercial interests that get together and say, hey, we're not going to make as much money as we would otherwise. Let's just come to some sort of agreement and then feed it, because very often, the regulators want industry to come to them with an answer. Has that ever happened? That industry has led regulation? Give me an example.

[00:49:34.28] JENNIFER A. MANNER: Well, I don't know if they've let, they've acted in response to avoid regulation. So I mean, you can look at Motion Picture Association, give ratings. That was such a well-known case.

[00:49:44.00] JP DE VRIES: But if everybody shares your pessimism that there isn't going to be any regulation, then there's no incentive.

[00:49:48.89] JENNIFER A. MANNER: But I will say the satellite industry, for better or worse, does have best practices.

[00:49:53.03] JP DE VRIES: Yeah.

[00:49:53.68] JENNIFER A. MANNER: And I don't know if the other associations and the rest of space because I'm not actively involved in them. But the Global Satellite Operators Association does have at least of recommendations. I don't know if there are best practices per se. And they've done that. Also, groups have come together on cybersecurity issues.

[00:50:09.11] So they have come together, but they're the least common denominator. Right? They're never going to be maybe the ideal solution. They're better than nothing. And there's something that people are willing to commit to. But you probably don't get to nirvana, so to speak.

[00:50:24.29] CAROLYN KAHN: And standards. So industry participates in the standards process, which is cooperative and important.

[00:50:30.80] JP DE VRIES: Before we go on, we can continue this conversation, I just want to check in to see if there are any questions in the audience. So let me just get a show of hands. How many questions we have? Good. We've got a couple of questions and we have a student question. So let's start with Andreas. And please introduce yourself by name and affiliation. And off we go.

[00:50:53.49] AUDIENCE: Hi, my name is Andreas Wilwerding. I'm a senior in aerospace engineering here at CU. I was wondering if there are any economic incentives that are in place in order to reward efficient spectrum usage or clearing of spectrum bottlenecks, or if those just aren't there, because using your spectrum allocation effectively is in itself an economic incentive?

[00:51:19.80] CAROLYN KAHN: So I mean, so secondary markets, auctions that have auctioned spectrum to commercial users and users. I mean, spectrum-- it's very much regulated. There's regulatory aspects as well as the economic incentives. And so they both play together. I mean, cost drivers are certainly an incentive.

[00:51:49.37] The more efficiently you use the spectrum, the more you can use it for additional and other purposes. So there are economic incentives there, but it works in conjunction with the policy because it is so regulated.

[00:52:05.69] JENNIFER A. MANNER: Satellite is a little different. And so we don't-- for the most part, we don't have auctions. There's only been a couple of times where satellite spectrum has been auctioned, and both of them have not been terribly successful.

[00:52:18.26] What does drive it is milestones. And the FCC has something called bond requirement where you actually have to meet certain build out requirements or you'll lose a multi-million dollar bond. But even at the International Telecommunications Union and lots of the licenses of operators and service providers have milestone requirements.

[00:52:38.51] So for instance, when I put in an ITU filing, I have seven years in which I have to use it. If I'm using certain very congested bands for NGSO broadband, I have additional milestones I have to meet. So there are milestones that require use of the spectrum.

[00:52:55.34] So maybe not perfect, but there is this idea that there should be-- spectrum should be used, it should be put to use. And governments do occasionally look-- and yeah, I mean, they're monitored. They're watched for what are people doing.

[00:53:08.60] JP DE VRIES: And just a follow on question to that, which is we talked about scarcity earlier. And scarcity is a function of technology because the technology changes scarcity changes. So for example, with water, I mean, maybe, does that play in water in the meeting you were in? Are people able to use water more efficiently? Hydroponics drip, they need less water or--

[00:53:34.40] PATTY LIMERICK: Right. We actually did a project on that, and it seems like it's 50/50. Water scarcity will cause people who are fighting with each other to say, oh, this is serious. We got to work together. There's a woman, Wendy Barneby was going to write a book about how water would be the next oil and international conflict.

[00:53:53.15] And then she went back to her publisher and she said, that's not working out because I am finding more international cooperation in water than I am finding fighting. And then the publisher said, well, the public's not going to be interested in that. I mean, who wants that?

[00:54:06.47] So I think there's a pattern-- well, it is about-- it was about 50/50 when we had a bunch of scholars together. 50% of the time, people fight like fiends over declining water resources. And 50% of the time, they say, we could fight over any number of other things, but we will-- this, we have to pull together on this. This is too important. So I guess, it's good that it's mixed.

[00:54:31.12] JP DE VRIES: Well, it also means, presumably, that we can't make a prediction about what's going to happen in space because it could go either way, you could flip a coin, they could argue, or they could fight. Sorry, they could agree, or they could fight.

[00:54:41.11] PATTY LIMERICK: Back to the applied history gospel, the fundamental gospel, the fundamental premise is it doesn't have to be this way. The way we conduct ourselves now, that is not destiny. We were not fated to be this way. So the water thing is great because it shows, well, here's one group going this way, one group going that way.

[00:54:56.36] So I think applied history is an anti inevitability delivery system. And we will slip into the inevitability if we don't watch ourselves. I did want to say, I forgot to mention, when I was talking about the engineers, I do have a solution to that. It's Limerick's laws for dinner parties that you cannot have a dinner party-- I'm not sure which regulatory body can enforce this.

[00:55:17.15] But you cannot have a dinner party until you've invited an engineer because you need to have someone there who says,

before we really get into conversation here, could I point out that the lights are on? And could I point out how that happened and where that resource came from and the places that you might drive by and think, oh, what an ugly power plant polluting the world? You might want to think about that.

[00:55:35.73] So before, well, I guess like every 10 minutes in the dinner party, the engineer would say, oh, another thing about the transport of the food that came here and that-- probably, did you do carbon offset for the transportation? So just having the engineer there just to say, do we have to invite him next time, I guess, is one thing that could happen with that.

[00:55:54.21] But just the bringing us to consciousness because we are so thick witted when it comes to where did we get-- well, GPS is just a spectacular example of that.

[00:56:03.14] JP DE VRIES: Very good. We have two questions. So now we've got four. We'll go with the first two. I think we had the first one there and then the second person behind. Go ahead. Yes, the astrophysicist lady. Sorry, I forget. UVA, was it? I forget the--

[00:56:22.28] AUDIENCE: I love that you remember my profession. Kelsey Johnson, University of Virginia I might want to maybe actually apologize for this question in advance, but I feel impelled to ask it. I'm mindful that we have at least one humanist in the room. I don't know if there are any others. I would love it if there were.

[00:56:39.61] I'm not sure we have any actual trained ethicists in the room. But I'm mindful that everything we're talking about impacts all of humanity, and I feel like those voices are really missing. And one of the ways that's impacted me is we've-- and at least three of the panels today, we've heard a version of, I'm a trained physicist, so physics gets the last word. I'm on board with that.

[00:57:00.91] But that economics gets the second to the last vote. And that's really hit me thinking about this wearing also a humanist hat. I also have an appointment in religious studies. And I'm wondering if our panelists could speak to in this hierarchy of things that have importance in decision making, if physics gets the last word, economics gets the second to last word, where does ethics fall? And how do we think about that? And what have we learned from that historically?

[00:57:31.00] Because humans really have a pretty terrible history of putting ethics in advance of progress, or what we might call in, air quotes, "progress." And I would love to know what you see as lessons learned and how we might think about that, just to open really a genuine dialogue on this because I think it's really important.

[00:57:50.94] JP DE VRIES: Go ahead.

[00:57:51.43] SURAJ JOG: So I guess as probably newest out of grad school person and probably the most naive one here, I would assume that the onus of ethics falls at each level. As a technologist, if I'm building something, part of my job is also communication of what I have built to the outer world.

[00:58:10.54] And there's a certain sense of ethics that I take upon myself, to be honest, in terms of its limitations or drawbacks, risks associated with what I've built. So I assume that it is my responsibility and because I'm the only one who knows this technology at a very deep level.

[00:58:31.24] The real world probably requires someone specific to monitor and to make sure that these lines are not crossed. But I'd love to hear what the other panelists have to say on this.

[00:58:43.39] JP DE VRIES: Patty? We'll just come down the line. Patty, Carolyn, Jennifer.

[00:58:46.10] PATTY LIMERICK: I would go totally cross-cultural and say this thing that we call economics is a very specific form of human conduct in a particular era of human history, and it is not universal by a long shot. So I would go kind of ethnographic on that of saying, not to say that we're going to treat you like a specimen, but it isn't something that has happened universally.

[00:59:10.06] And in fact, many of the methods-- and that's why you guys get Nobel prizes, because you come up with new ways of doing it and so on. But I think it's a way of saying, this is what we're going to pay attention to that people have done in very broad ways. I mean, I know the name Kyle Bronner because he seemed to be able to-- just think, who would I be if I weren't an economist? And how would I be thinking? And how could I then speak to that population?

[00:59:35.69] But I just think we want to go into historical perspective and say, this is a custom that is called being an economist, and that's what it is in the 21st century and was through. But that is not a universal human conduct. We cannot say, oh, we see the same thing in ancient China, or we see-- it's just so historically specific to a time.

[00:59:56.45] So that's what I would say is-- I mean, I don't quite know where they would go in the rank order of who is at the bottom of what list. But it's just the time is to say, who are these people? And then I would say to go into a full out empathy to say to you, and we don't have time now. We can do it in the reception.

[01:00:14.62] Why do you want to be an economist? And what was your dream to be a narrow and only communicate with you-- get to have any PowerPoint slides today. What were you hoping to do with that? And I'm going to guess it would be to make a better world.

[01:00:28.64] CAROLYN KAHN: It was. And what I loved when I was a student studying economics was how supply and demand and all of

these different system dynamics just seem to work perfectly. And I was in awe of that. And the more experience I get, the more I see the challenges. And so now I'm driven to help to where the economics breaks down, and that's where policy comes into play.

[01:00:52.56] But I think ethics also is-- different communities and countries have different perspectives on ethics, and so I think coming to agreement. And I have seen some of that in some of the international agreements with equity. And I mean, there is an incentive for developing nations to have communications. And that helps-- that helps the world as well and other countries. So there are some drivers there.

[01:01:22.00] JP DE VRIES: Yeah, thank you.

[01:01:23.06] JENNIFER A. MANNER: So I guess, I can't really speak on ethics, but part of what drove me and my interest on scarce resources, which is really what I'm interested in more than anything, is this concept of how do you share these resources among different nations? And you look back to the Outer Space Treaty, the Outer Space is for the province of mankind.

[01:01:42.20] You even look back to John F. Kennedy when he formed COMSAT, which became Intelsat, one of the large inter-governmental satellite organizations, his goal was to have all of mankind connected. You still look at things that are going on today at the ITU, there's an agenda item for the WRC on equitable access to spectrum.

[01:02:03.80] Whether you think it's the right way it's going about or not, I think there's no denying that people think that countries should have access to adequate spectrum. So I do think that's included and that's part of the conversation. It's just that not everyone has the same view on how to get there, or the best way to get it or what that is.

[01:02:20.65] PATTY LIMERICK: So could I just say? This reminds me so much of that famous phrase from Moliere that the person who realized he had been speaking prose all his life. Well, these two people are ethicists. What they just said, I would say, those were ethical statements they made.

[01:02:34.06] Now, you actually began by saying you didn't really do ethics and you just spoke ethically. So you've been speaking prose all your life, and you've been an ethicist all your life. And you can ignore that or-- but you're not ignoring it. That's the whole point, is that you're living it, which is better than saying that you are that, because there are people who say they're ethicists and you wouldn't know it from their conduct.

[01:02:59.49] JP DE VRIES: And that is a wonderful place at which to end. We're at time. I know that there are still some questions in the room. What I encourage you to do is to go to the reception,

buttonhole somebody and ask them your question. And let's continue the conversation. Thank you very much to the panel.

Day 2: June 25, 2025

Keynote: David Goldman, VP Satellite Policy at SpaceX

https://youtu.be/vwShfBtDRWw?si=jtpUSpAO7nC7ZoKy

[00:00:01.28] HOLLY CHAVET: Good morning, everyone. Thank you all for being here today, traveling from near and far to engage in this important conversation with us. My name is Holly. I'm a TU here at Colorado Law and President of our Space Law Society. It is a privilege to be here today and introduce the final keynote speaker of our conference, Mr. David Goldman.

[00:00:22.73] Mr. David Goldman is the vice president of Satellite Policy here at SpaceX. David brings a wealth of experience from the public and private sectors, having shaped key developments in communications and spectrum policy over the past two decades. Before joining SpaceX, he held several key roles across the FCC and on Capitol Hill, shaping important policies around spectrum, wireless, and public safety. Please join me in welcoming Mr. David Goldman.

[00:00:53.22] [APPLAUSE]

[00:01:03.26] DAVID GOLDMAN: Thanks so much for that. Thank you very, very much for having me. This is such a great conference. Really I love seeing this. I think there really needs to be a lot more academic engagement in space law. This is such a great thing to see. I'm really excited about it. And thanks to Pat and Dale for your announcement yesterday, that really-- I mean, that's amazing. I'm really excited to be here for all of this.

[00:01:36.04] I have to say, I think I already have had my highlight from the conference is just the number of students and young professionals who are doing space stuff now. It's really been overwhelming and really inspirational. I've tried to engage with schools before and trying to do things, and I'll meet a lot of students and I get really excited, and then I talk to them and it's like, yeah, well, this is kind of interesting, but I'm going to go do something else.

[00:02:01.24] This has been kind of amazing to me-- the number of people newly out of school or still in school who really want to get engaged, and it's really with a lot of new thoughts. And it's giving me hope in a way that it really is like motivating me to keep going. So I really thank you so much. Let me see. I got this going.

[00:02:28.51] So quickly-- I was asked by SpaceX to make sure I explain what Starlink is. I think that this room probably has some idea, but we operate a low Earth orbit satellite constellation that provides high speed, low latency broadband pretty much anywhere in the world. Yeah, I mean, I think anywhere in the world.

[00:02:52.21] We're able to reach places that other people-- that other technologies can't. Let me see. Thanks. OK. We've been growing pretty quick. We are now-- we have over 6 million customers around the world. We're in over 140 countries. I feel like it's every few days we're announcing another country that we're moving into.

[00:03:16.68] You'll see as we're growing, we're starting to push more. This is a little bit old. We're starting to push more into Africa, which is actually one of the things I'm really excited about, is we're pushing more and more into Africa and Southeast Asia. That really is like when you're talking about the 3 million people who still aren't connected.

[00:03:35.46] That's really where a lot of them are. And we're doing a lot of work right now to try to really push into those regions, which is really exciting to me because we're getting to see people who really, really have no other options. And you think about how many really talented, great people are out there that can't get the kind of access to education, can't start businesses with reach outside of their village, and now we're being able to get there. It's like it's really exciting to see where this is going.

[00:04:03.58] All right. So I did want to start turning some of the focus from looking up to looking at what's actually happening on the ground. A friend of mine at SpaceX, actually is an aerospace engineer who graduated from here from Colorado, and she was part of our Polaris Dawn mission a few months ago, which was the first private spacewalk. They had a totally private crew, we had a few SpaceX employees on it, that not only went into orbit, but actually opened up the capsule and went on a spacewalk.

[00:04:35.96] And one of the purposes of their mission was to raise awareness for St. Juste. And one of the things they did was they went around the world, and one of the places they went was to the Philippines, to help raise money, raise awareness, raise funding for St. Juste in which institutes. They're focused on Children's Cancer.

[00:04:59.25] And in the United States, it's an 80% survival rate for Children's Cancer. Outside the United States, the stats reverse. And they went down to the Philippines. One of the big issues they have in the Philippines is there's a big hospital in Manila that actually they have great researchers, doctors who are trained on what to do, but it's really hard to get around the country.

[00:05:22.60] And so for families who have children who have issues, it could be hours, 3, 7 hours to drive to the hospital. And there's clinics all around the country, but they don't have the same kind of resources that they do at the hospital.

[00:05:37.87] So one of the things that the Polaris Dawn crew did is they went down there and they brought a bunch of Starlink terminals, and they brought them out to these clinics that are the far reaches of the country. And what they were able to do was get the doctors who

are good doctors at these clinics, but they didn't have the same resources.

[00:05:56.32] And what they were able to do with the Starlink connection is that they were able to now reach back to the Central Hospital and anywhere in the world, and be able to diagnose faster and find treatments faster and start helping the survival rates go up.

[00:06:15.09] So Sarah, who went and did this, was telling me how inspiring it was to see the people in the Philippines who had been so committed to doing this, to be able to now have new resources, new tools at their fingertips, to be able to really help.

[00:06:28.53] So one of the things you can do when you don't have to rely on the infrastructure on the ground, when there was the La wildfires a few months ago and people were being affected by fires, who never expected that that was going to happen, the traditional connectivity all went out. And we were able to send in about 1,300 or so user terminals to public safety, first responders to shelters. And we actually provided free service to anyone who had the kits.

[00:07:00.86] And it helped public safety mobilize. It helped find victims. It helped connect families for those first critical days when there just wasn't really any other option. Similarly, in Spain and Portugal, when the power went out, everything else went out. And what we saw is when everything else went out, our usage spiked. It shot up about 35% immediately afterwards.

[00:07:26.57] And what that was is that a lot of people actually had our user terminals as backup, and when they didn't have another option, they were able to turn this on and be able to connect when they had no other options.

[00:07:39.43] And then I personally actually recently had an experience. I got to go to Kenya. And the president of Kenya is-- one of his initiatives that he's trying to do is he wants to push more government services online. A lot of the government services are very inefficient. They're hard to reach. And like his goal is to be able to put a lot more of these government services to be more accessible online.

[00:08:02.80] The problem is, in most of Kenya, you have a very hard time getting internet connections. So he's actually been very supportive of us trying to push Starlink out as far as we can to as many people as we can. And one of the things he asked me to do when I was there was to go meet with the head of the Parks Department.

[00:08:21.06] And so we drove over there and we were talking in the car, and I had no idea what I was going to talk to him about. We weren't prepared for it. But actually we got there and he was amazing, the head of the Parks Department. He actually was prepared to present to us that last year, he had bought a number of our terminals and put them on the gates of all the parks across the country.

[00:08:43.54] So everywhere, if you were to go to Kenya to go on Safari, this is where you would go. And so these parks are in far flung areas of the country, really remote. There is no other kind of connectivity. And what he said, he put these terminals on the gates to every one of the parks. And so then you had Wi-Fi when you were coming in.

[00:09:01.72] And up until then, to get into a park, you had to pay in cash because they didn't have any connectivity. They then switched all the payment to apps that you had to download their app and you pay. Revenue to the park went up 10X. There was that much inefficiency that was going on. They were getting 10% of the potential revenue into the parks because of whatever was happening in the transaction there.

[00:09:28.53] But the other thing, once they had that, once they realized they could do is they started actually putting a bunch of these kits out in the parks where they have cameras, where they know where the poachers are going, but they don't have connectivity to those cameras. So someone, a ranger, would actually have to go at night and pick up the memory from the cameras and see what happened.

[00:09:48.50] By attaching these terminals to the cameras, they were actually starting to be able to track down poachers in real time and be able to actually stop it before it happens, rather than forensically figuring out what happened afterwards. But then he told me, this is like they're so kind of public interest oriented. They leave all of the terminals on because there's villages all around there and they don't have anything either.

[00:10:14.07] So they just leave the terminals on. It's basically free broadband to the local communities. And he was showing me pictures of people coming out with their phones that the whole village comes around. We've seen kind of in the United States of people going to the McDonald's to get the Wi-Fi. This is like the whole village, there was no other option. This is how they were getting it.

[00:10:30.21] And so you just start thinking about all these uses. I mean, I didn't think of it. I don't think when we were developing, when we were working on Starlink, these are not the kind of things that we were thinking about. And it's amazing to see when you have this new technology, what people can do with it.

[00:10:44.97] And so I don't say all these things as a commercial for Starlink. Well, a little bit of commercial for Starlink. But we may be the first doing a lot of this, but we really got to make sure we're not the last and the only. We need to think about how do we encourage more innovation like this. How do we use space better? How do we keep innovating?

[00:11:10.39] And access to space at this point is it's much less expensive than it has ever been. There's more launches. There's more abilities to get to space than ever. How do we use those lower barriers

of entry to actually encourage the innovation? And I think actually from where I sit, the regulations are starting to be the barrier. That's where the bottleneck is.

[00:11:37.82] And I'm not here to say, oh, so get rid of all the regulations. It's actually I'm going to say the opposite of that. But I do think we need to rightsize them. I do think we need to upgrade them. A lot of the regulations are decades old. They're for when launches were happening every several years.

[00:11:54.82] I worked in and around the FCC for a dozen years where I actually didn't know that the FCC approved commercial launches, because in that time, there was no commercial launches. Now we're going every two days. So we're just in a totally different world than from when a lot of these rules were in place. And I think we have to start thinking about how do we upgrade them, how do we start matching the regulations to the world that we live in now.

[00:12:23.79] So I started thinking, so from the startup summer here, what if there was a couple of students who would came in and said, hey, I want to actually do a space startup, I want to see if there's a way to be able to use this increased access to space to do create one of the startups like startup summer is famous for but to do it trying to leverage space.

[00:12:53.87] So first, there's a couple of things. One of them is, if you were doing a terrestrial thing, you wouldn't-- if you want to do an online business, for example, you wouldn't have to think of how do I trench for fiber, how do I build a tower? Like, that's all there. For a number of reasons, the policies for space actually push you that you probably want to build your own system. I don't think you need to do that, but I do think a lot of our policies do push in that direction.

[00:13:17.85] And so the first thing you would have to do is start figuring out how am I going to build and fly satellites, how am I going to start building a ground network, how am I going to build user equipment, and that's before you get to the actual business part of it. So I think that's one of the things we should be thinking about.

[00:13:32.49] But assuming you get that far, what's the next step? And so I started thinking, what would be a potential business that could be coming out of the startup? I'm assuming one potential business is like a Earth monitoring to track Dionne, to see recruiting. I assume that has there's some money in that.

[00:13:56.99] And so if you wanted to build a system-- sorry, this is actually kind of loosely modeled off of some of our launch customers we have on some of our rideshares. We launch rideshares, where you can share a launch with a bunch of other small satellite operators and lower the cost for anybody. And so these numbers are all kind of loosely built based on actual customers that we have.

[00:14:20.27] So if you want to do, say, 12 CubeSats, the next possible launch that you could get on is scheduled for February 27. We actually just had one of these transporters the other day where we had 70 different satellites that we launched. So you can get on at about-- there's an available spot, February 27. A few months later, you can get another one. Total launch fee is about $2 million to be able to do that.

[00:14:44.14] So assuming that our students call Dale and say, let's get rid of the new professor, and you can sponsor a whole new Colorado constellation. And so Pat and Dale say, that is a better legacy. Let's do that. Especially when they find out about the Dian thing.

[00:15:07.54] And so you're saving money, you dont put propulsion on it. I don't recommend that. But let's say that's what we do. We launch, we don't put propulsion on, so the rocket drops you off, or it takes about five years of a passive deorbit. The licensing fees for that system probably are a quarter of a million dollars more over that five years than your launch fee.

[00:15:32.55] Also, just this is not-- the FCC is doing really incredible stuff. The space bureau like was it-- Chairwoman Rosenworcel creating the space Bureau really was a lot of foresight. I know Julie did some amazing work getting that started. I think Jay, who's there now, is really taking it and running with it. I've been super impressed with it, but they are pushing against a lot of legacy regulations and norms that make it very difficult.

[00:15:58.29] And so this data is a little bit old, but based off of just historical numbers of how long it takes for the FCC to process a license, you probably-- if you filed today, probably don't get your license until September 27, which means you missed your launches. And if you talk to a lot of space startups, you miss your launch, you run out of funding. You probably don't go. That's not a delay. That probably just doesn't happen. So we have to rightsize this. It shouldn't cost more to get your license than it costs to launch.

[00:16:34.31] So the other thing that happens though, when you get your license is typically, at least in our experience, a lot of our customers experience, our launch customers experience is the licenses tend to come very close to when you actually launch. And so you say, OK, that's fine, at least you got your license. But the thing is that these licenses come with conditions.

[00:16:54.76] And so you get your license, by the time you get your license, you probably had to develop, build, and actually ship your satellites to launch site by the time you got your license. So you get the conditions on your license and then you have to go quickly read and find out whether you actually built the thing that you're allowed to go fly.

[00:17:10.40] And these conditions are not trivial. I know was some conversation yesterday about spaces unregulated. These were the

conditions on our last license. There was 12 pages of conditions there. It goes up, I think, to quadruple J. And by the way, that last condition in the bottom right corner says also we're importing all of the conditions from all of your other licenses too.

[00:17:35.33] So it's fine. We have a legal team. Like for us, we can sit there and we can read through this and figure this out. But if you're a small business, if you're students, this is a big scramble to go figure out whether you do it. And we have launch customers. This happens where you get this or you get questions a few weeks out, you get calls from the FCC where it's not necessarily written rules, but it's kind of FCC practice. And they call and say, well, what are you doing about this? What are you doing about that? That could be the end of the business.

[00:18:06.60] And you could say, OK, well, this is all boilerplate. It's actually not. We did an analysis on this. It's actually highly unpredictable which conditions you're going to get on your license. We compared for several years worth of licenses that came out, and we were running them up against each other. I'm sure there's some reasoning between who gets what conditions, but large constellations didn't get some of the space sustainability conditions that we got while constellations of like, eight satellites did.

[00:18:38.97] I mean, it's just consistently like this. It's really hard to know what you're actually going to get. So this is not trivial. So what I wanted to suggest is that we start thinking about how can we update these rules to start encouraging and lower the barrier to entry on the regulatory side to match the lower barrier to entry on cost and technology.

[00:19:03.35] And so one of the things is current rules-- this regulation by condition is it ends up being very ad hoc and very hard to predict. So if you're the students building buffs ad, you're sitting there and you're saying, OK, well, let's read the rules and figure out what do I have to build around. You can't really know in advance. You have to wait. And so you build at risk and hope that it works out.

[00:19:25.92] So I think we need to start thinking about how do we standardize these rules, make them more predictable. Maybe people need waivers. And we can spend the time thinking about how waivers could work. But the initial set of rules, I think we need to start making it more understandable up front and more predictable so you know when you're building your system, what rules you're building to.

[00:19:47.96] Engineers are really creative on how to solve problems when you tell them the limits that they're building against. But if they don't know, they sit there and they just are guessing and it creates a massive inefficiency.

[00:20:01.36] So I had a few ideas to suggest of things that we could be doing. For example, I didn't even-- when I was talking about the space stuff, I didn't even get into the ground stations. So if you need to

start setting up ground stations, it's each one is individually licensed. They do interference checks on all of them, even though at the frequencies that a lot of these things are operating, the chance of interference is almost nothing, especially when you push up into the higher frequencies.

[00:20:27.62] Mostly you just need to know where the other systems are, the other stations are. And make sure that you're not piling on top of each other. And so what if we moved to a light licensing model, that's this does not have to be a fancy dynamic database, just a regular database kind of system where you go check is where I'm going to build. Is that going to be on top of someone else. And if not, we're OK. So that can speed up-- it actually help FCC processing. The ground station, the gateway applications can take over a year to process on their own. So you can accelerate that dramatically.

[00:21:03.36] Sunsetting outdated protections. This is all shared spectrum that we operate in mostly. And there's a lot of protections that are kind of in place to protect the initial investment. But there's got to be a time where at some point, we're starting to make it easier for new entrants to start being able to build in there, too.

[00:21:22.57] And we actually suggested for our own license. As a matter of fact, for our initial Gen 1 system, we suggest in subsetting our own protection. I may be the first dumbest person at the FCC to go actually into the FCC and say, actually, sunset our own initial protections, but I think you have to. And so start looking at these incumbent protections, how do you wind them down over time.

[00:21:46.29] And what that does is it actually creates an incentive for both sides, the new entrants and for the incumbents to come together and try to work and see if you can figure it out amongst yourselves, because both sides at that point have an incentive. If you have the protection for some amount of time, the new entrant says, well, if I can get an agreement now, maybe I can make my situation better.

[00:22:04.74] And if you're the earlier, you're the incumbent, you can say, well, if I get a deal, I never will have more leverage than I have now, maybe I can get a better deal by doing this today rather than waiting. And so I think by sunsetting protections, you're also driving the industry to work together to actually solve their own problems.

[00:22:20.42] Encourage more both infrastructure and spectrum sharing. I have them in one bullet because it both said sharing. But these are actually two different things. Infrastructure, like I said earlier, there's actually a lot of the rules push you to have to develop your own integrated top to bottom system.

[00:22:38.45] It doesn't have to be that way. We can make it much easier on ground networks to share ground networks. Right now for gateways, you actually have to apply for each and every one of your gateways for a new point of contact, new satellites you want to talk to.

[00:22:57.68] That means if you had say you wanted to do gateways as a service, if you had six clients and hundreds gateways, that's 600 applications you have to do. I think we can make it easier than that. Also hosted payloads. Like, it's not easy to get a hosted payload approved to be able to put your antenna on someone else's satellite. That seems like that's just good in all ways, honestly.

[00:23:19.35] You have fewer satellites into independent satellites that are flying. If you're the students, you don't actually have to go hire aerospace engineers. You can just attach to someone else's system. Enforce deployment requirements. Accelerate harmonization is I'm throwing a little bomb, but it's can we get the ITU to move a little faster? The ITU is becoming totally irrelevant.

[00:23:43.63] And strong, consistent rules for sustainability. I'm sorry I wasn't tracking my time, so I'm sorry if I'm running over. Space sustainability in particular, I think this is a place where we can-- let's get some more strong rules in there that are predictable and it's not as much ad hoc.

[00:24:02.65] But I also-- we put up this picture on purpose. So the top half of the Earth there, that is from an OECD presentation of talking about space sustainability. The bottom one is actually a real picture of space from the Polaris Dawn launch. We probably have hundreds of satellites in that bottom picture.

[00:24:26.63] There are real things that need to be done on space sustainability. It's a real issue that needs to be talked about. But when you say that space looks like the top picture when it actually looks like the bottom picture, you're not having an honest conversation about it.

[00:24:41.28] Now, I do want to make an exception. The picture for this is spectacular. And my understanding is this came from Peter Ten Hula going to AI and saying, can you create an image of satellites the size of small continents?

[00:25:06.77] And then when he got the picture, he said, that's not-- can you create some more dragon fire?

[00:25:11.77] [LAUGHTER]

[00:25:14.93] So while I'm complaining generally, this one I am not complaining about because this is how you do it.

[00:25:26.95] But a lot, a lot of what needs to be done on space sustainability is actually communication. It's transparency. It's that operators are talking-- I'm sorry. I'm going to try to accelerate so I don't use up all the time. But it's about transparency working together, actually telling people where your satellites are. There's a lot that can be done just by enhancing transparency and working together.

[00:25:48.70] It's really, really a problem. There are not traffic rules in space. Like, we really got to start figuring these things out. Talking

about OneWeb is licensed in the UK, we're licensed in the United States. If we have two satellites coming out at each other, do you pass on the left or the right. We need to really, I think, but if you can put in rules up front that people can understand, then you can build to the rules.

[00:26:14.71] When it comes in late and you get conditions on your license that you don't know whether you're going to get them or you're not, it's really, really hard to build towards it. It is not creating the right incentives. It is not-- when some people get a requirement and others don't, you're pushing all those requirements and all of that action onto one operator. The other operator gets a free pass. It's not creating the right incentives. It is not encouraging everyone to be as responsible as possible.

[00:26:41.27] So just to close out, I'm not sure that all of these things that I'm suggesting are the right things, especially, like I said, I've met some incredible students, some incredible kind of young professionals here. I guess my ask is for you guys challenge what I'm suggesting, tell me why it's wrong.

[00:27:00.63] But also really, really the status quo really challenge whether those are the right things when you're learning this stuff. I know it's a steep learning curve. I know you're learning a lot and it's presented as this is the way it's done. Never accept that that's right. Question whether that is the right-- what we're doing is the right thing, and whether we can do it better, because I promise you, 100% of the time there's some way to do it better. And we should be looking for those ways. So anyway, that's the end of that. Thank you so much.

[00:27:24.97] [APPLAUSE]

[00:27:30.00] PRESENTER: Yeah OK. Well, we have time. All right, Andreas, you're on. Are you going to-- are you going to run buff set now that you've heard about the idea?

[00:27:45.26] ANDREAS: That's a good idea. I don't know where it is. All right.

[00:27:49.03] DAVID GOLDMAN: Right. Exactly, there's money in that. People will pay.

[00:27:53.85] ANDREAS: OK, so my name is Andreas. I'm a fourth year aerospace engineering student, and I was wondering, how is SpaceX navigating, like the regulatory or licensing differences between Starlink and Starshield? That's being.

[00:28:12.65] DAVID GOLDMAN: Yeah, that's-- let's not do the Weiser Rule.

[00:28:18.23] [LAUGHTER]

[00:28:25.40] No, they're actually really different because it's-- on the Starshield side, it's a lot of government authorization. So it actually it runs-- a lot of that runs more through the NTIA side. So it actually is-- they really are. It's like a different licensing because it's when you're operating for the commercial, you go through the FCC and you've got all the commercial rules for the government side.

[00:28:45.87] When you're going through NTIA, it's like a different-- it's just a whole different process. So they're actually they're kind of parallel. We run it's similar hardware but it's not exactly the same. And so it just gets licensed different. It's not a satisfying answer, but it's just what it is.

[00:29:04.60] PRESENTER: No question. Let's go back to Kelsey.

[00:29:13.60] KELSEY JOHNSON: Kelsey Johnson, University of Virginia. First, I really want to publicly thank, on the record, Starlink for being really good partners to astronomers. Of many of the satellite companies, I think Starlink has really gone above and beyond what's been required to work with us, and we really appreciate that. So I want to call that out and send some kudos your way.

[00:29:35.65] But I want to follow that up with maybe a little bit of a hot potato, after I've softened you up and thanked you. I think the use cases you presented for Starlink are really compelling, and I think everyone in the room, including me, is on board with bridging the digital divide. Like that's really important. In fact, it's baked into the mission statement of the American Astronomical Society and sharing things with all of humanity.

[00:29:59.30] So I want to express that, we really are supportive of that. But there's also a hidden reality here that I think PR firms are really good at hiding. And that is that the overwhelming majority of internet use is for high definition videos. A substantial fraction of which is pornography, online gaming, and online shopping. And that's really where the internet use is going.

[00:30:24.91] And if we want to make the case that the reason we have satellites is to bridge the digital divide, I'm on board with that. But that doesn't take tens of thousands of satellites. And so I think the question is, and this is maybe for everyone in industry, can you make an assessment of if-- and I realize this isn't a viable business model and there's a reason I'm not in business, among many other things, I don't really care about money.

[00:30:54.45] If all you were trying to do is bridge the digital divide, how much internet would that take and how many satellites would it take? Because I think it's far, far South of what we're predicting will happen.

[00:31:06.35] DAVID GOLDMAN: Yeah, so first, thanks for the nice part. And it's true, by the way, just National Science Foundation and

NRAO have been just amazing, amazing partners on working on how to mitigate harm to astronomers. It's one of my favorite parts of my job is getting to work with them. It's really been incredible.

[00:31:34.79] This is true. I actually now bring my kids to radio astronomy sites on vacation, which they tell me they like. But I mean, I brought him to the very large array recently. It was super cool for me. Yeah, so to the other-- I mean, I don't have the data on what people are using internet for.

[00:32:03.12] I think we saw those use cases. We don't have a PR firm, by the way. Those are ours. You really do need high speed internet. And it's not just us. I mean, we should have other systems out there. I think we can-- it's not about number. There's things you can do to mitigate.

[00:32:21.88] You can have a handful of really bad satellites. I think the focus on the number of satellites is missing the issue. You can have a handful of satellites that are too bright or too noisy or whatever, are not flown well and can be extremely risky. You can also have a bunch of satellites that are run responsibly and mitigate these problems, and actually fix people's real problems while you're mitigating the effects on others.

[00:32:51.68] So I think actually the focus on numbers is kind of missing the point. What we need to be focusing on is how do you make sure that people are operating responsibly so that you can deliver the good stuff. And I'm not going to put a value on judgment on whether people are using their internet correctly. It's not for us to do. There are definitely good use cases is that are-- I mean, look how much money all the governments around the world are spending on trying to deploy high speed broadband. And all I ever hear is that our speeds are not actually fast enough.

[00:33:22.26] And so, yeah, I think what we need to be thinking about more is how are we using space responsibly. How are we maximizing utilization of space for things on the ground. Not just services, not just broadband, but for space exploration, for astronomy, how are we maximizing it. How are we trying to come up with the right incentives for people to be operating responsibly and efficiently so that we can provide the goods that-- the good services that people want, while you're still allowing for space exploration, for while you're still allowing for all these other things.

[00:33:54.97] I think it can be done. I don't think it needs to be zero-sum. I don't think you have to say it's one or the other. I think we can have both. I think we can be good enough that we can have both services, both sides of it.

[00:34:05.15] PRESENTER: Please help me thank David for a very thoughtful, stimulating presentation. Thank you. Thank you.

[00:34:10.86] [APPLAUSE]

Panel: Dark and Quiet Skies

https://youtu.be/UoRLKEFgFro?si=rcEycSGKQweS0ZoL

[00:00:00.44] BRAD BERNTHAL: I will introduce our moderator, and other introductions will be handled by Chris. Chris joined. ITS in 2023, following a distinguished 16-year tenure in the United States-- at the United States Naval Academy as an associate professor in the Electrical and Computer Engineering Department. And in June of 2024, he was elevated to ITS Theory Division Chief. Over to you, Chris. Thanks for being here. Chris.

[00:00:24.93] CHRIS ANDERSON: And as of April 30th, I became the Acting Measurements Division Chief. So I got to wear two supervisory hats now. So thank you, everybody. I think we've got a really dynamic panel. We've had a lot of good discussions going in some of our preparatory sessions.

[00:00:44.72] But basically, we're talking about dark and quiet skies. And as a bit of an opening statement or as a way of an opening statement, as the humanities-- as our presence in space accelerates, the sky is becoming busier and brighter, both from an optical perspective as well as a wireless spectrum perspective.

[00:01:07.09] Rapid deployment of large satellite constellations that are going to be essential for global connectivity and commercial innovation has created a growing tension that we've seen in this conference, with efforts to preserve shared access to the night sky.

[00:01:23.11] Both optical and radio astronomers faced increasing interference from reflected light and electromagnetic emissions, and Earth observation systems grappled with degraded measurement accuracy. These challenges are compounded by growing concerns about orbital debris, which we've also seen discussed at this conference. And the sustainability of single-use satellite deployments.

[00:01:46.69] So what we're going to try to do in this panel is explore the increasingly urgent question that, how do we sustain space as a shared resource, both balancing commercial growth with the preservation of critical, scientific, environmental, and public interests? And we're going to examine competing priorities and trade-offs that are at the heart of the issue. How can science and market forces align to protect our dark and quiet skies?

[00:02:15.35] And we've got a number of very knowledgeable people on the panel here, just by way of a quick introduction. So we have Ashley VanderLey as an independent astronomer today. We have Jessica Heim from the University of Queensland, PhD student. Is that correct? We have Kelsey Johnson from the University of Virginia. We have Zack Donohew from the University of Colorado Boulder, and Paul Kolodzy. Paul, what hat are you wearing today?

[00:02:48.97] PAUL KOLODZY: Logos.

[00:02:49.76] CHRIS ANDERSON: Logos.

[00:02:50.54] PAUL KOLODZY: State services.

[00:02:52.62] CHRIS ANDERSON: So I'm going to allow the panelists to-- or ask the panelists to provide a brief opening statement, and then we'll start going into discussion. So Ashley, you're up first.

[00:03:05.60] ASHLEY VANDERLEY: Sounds great. Thank you. I really appreciate the invitation to be here, and Keith, for continuing to twist my arm. It's fantastic. So I am here in my personal capacity. But come-- just I wanted to share some of my personal reflections on this topic, both working at the National Science Foundation for eight years, also serving as the US lead to the ITU for Working Party 7D on behalf of the State Department.

[00:03:31.96] Also, serving as a board member on the American Astronomical Society. And so just observing the issues and ways that we can actually work together to solve this problem and continue to explore and solve the really important problems that David pointed out.

[00:03:52.73] One thing I wanted to point to you all to, if you did not see the news this week. The Rubin-- Vera C Rubin Observatory had its first look on Monday. Absolutely fabulous images. If you go to rubinobservatory.org or the skyviewer.app, you can actually explore these images yourself.

[00:04:12.26] The reason I wanted to point this out is they're absolutely just beautiful and stunning. So it would take over 400 high-definition televisions for your eye to take in a single 15-second exposure from the Rubin Observatory. It's eight square degrees, which is about the area of 45 full moons. So you can see how big this image is.

[00:04:35.61] And it's not new, the fact that we know that space that otherwise looks completely empty, is full of stars and galaxies that we can learn from. We learn this from Hubble. But Hubble, taking about 1.6 million images, only has observed about 1%-- far less than 1% of the whole sky, where Rubin, over a 10-year period, is going to have this exquisite ability to learn from the sky-- over 50% of the sky. So creating a 10-year movie.

[00:05:05.39] So I really wanted to say thank you to the satellite operators. One of the big things, when we think about space as a resource, we've been thinking about the impacts to radio astronomy, but also the impacts to optical and infrared astronomy. So in optical astronomy, astronomers are used to removing satellite streaks from their data.

[00:05:24.25] So one of the big challenges was to just ensure that the brightness of any particular satellite was not so bright that it caused

nonlinear effects in the largest CCD camera ever created for Rubin. Because if that happens, you've actually ruined the entire image.

[00:05:40.30] But if it's actually faint enough, which we determined-- originally, we thought it was about seventh magnitude, which is about the limit that your naked eye can see. We're moving that down probably to six or six-and-a-half magnitude. So there's ways of doing that. But I wanted to really point you to that. I think it's absolutely beautiful, and I think you'll enjoy exploring those images.

[00:06:00.26] I also wanted to just point out that the Rubin Observatory is going to be detecting many asteroids. So currently, we know of about a million asteroids in the asteroid belt. It's a big concern for the American population and the whole world, if we have a dangerous killer asteroid of a certain size come and hit the Earth. So it's actually congressional mandate to discover and characterize asteroids of a particular size.

[00:06:25.17] About a million are known. They expect in the next couple of years, Rubin is going to be able to detect and characterize millions. So we're looking at probably five million more discovered. So really good characterization. But that also shows that objects in space are not necessarily destroying our ability to see through that asteroid belt into the broader. We just need to know how to characterize and remove it from the data. So I did want to highlight that as a good that astronomy provides to all of us.

[00:06:56.12] Yesterday, there was a lot of discussion as well about economic inputs and things that we all benefit from. And so I think many of you know this, but I did want to highlight from the radio astronomy perspective. One thing that radio astronomy has provided that is not fully appreciated is contributions to understanding how the Earth is oriented in space.

[00:07:17.45] So we all rely on GPS, but what does GPS rely on? We have to know very precisely how the Earth is oriented. And if you have star trackers on your satellite, that's great. But stars also move. And so it actually takes observations of very distant galaxies and the black holes at their centers, which do not move on the timescales that we care about to get the most accurate position for the Earth.

[00:07:39.80] So this is one thing that we do with our radio telescopes, including the very long baseline array and an international array of telescopes. It's just observed black holes over and over again to establish that celestial reference frame, so that we can have the high-precision GPS that's needed.

[00:07:56.46] And so for everyone that says, why should I work together to help protect radio astronomy observations and ensure this is possible? It's because you're all relying on that fundamental reference frame for the satellites that you operate, and also the cell

phone in your pocket. So that's really important. And I wanted to highlight.

[00:08:16.50] So some of the frequencies that are currently used are acid x-band, which is two to four gigahertz and eight to 10 gigahertz. Folks are looking to move up to higher frequency bands to be able to avoid some of the interference.

[00:08:28.58] A couple more quick comments. I just wanted to highlight one thing that I think is really important. Folks have used modeling for a long time as the way to determine if compatibility is possible. And we really think it's important to go from modeling to testing. Essentially, let's use the scientific method. The model is your hypothesis. Now, let's test and see if that works.

[00:08:51.14] And oftentimes, you'll find that they are. The models are toy models. They make a lot of simplifying assumptions. But in the real world, we might be able to actually find better solutions, as was referred to yesterday.

[00:09:02.02] One example, folks asked about dynamic sharing as it comes to satellites. And we have some fantastic news on stuff that's been published by a number of astronomers, including NRAO and in collaboration with SpaceX. And we're looking to work with multiple satellite companies on this. But it's called the Operational Data Sharing System.

[00:09:21.67] So initially, looking at downlinks for the fixed satellite service from 10.7 to 12.7 gigahertz, satellite operators have to coordinate with the National Science Foundation. There's a rule. It's US 131. It's very generic, what that coordination means. There's a tiny, tiny radio astronomy band.

[00:09:39.88] But astronomers actually care about the entire bandwidth. They observed from one to 115, wherever the physics and the science takes them. So there's the most important bands that are protected. But you do want to have access to the sky as much as possible everywhere.

[00:09:54.96] So initially, we thought, OK, let's say, no downlinks in the whole state of New Mexico, will that protect the Very Large Array, where David visited? Well, it turns out that does not protect as well as if you can actually dynamically protect with boresight encounters.

[00:10:13.89] So if you know precisely where the telescope is looking and where the satellite is pointing, and you can do very precise coordination, it turns out you can bring in the satellite service within just a mile or two of the telescope. And so you're able to do your scientific observations and provide service.

[00:10:31.35] And so if we proposed that initially, it would have sounded crazy, very, very complicated machine learning machine to machine. But this is now fully implemented at the VLA, and they're

doing hundreds of maneuvers every week. SpaceX, and there's a number of other satellite companies that are working to implement this. And this is beginning to get rolled out more broadly.

[00:10:53.21] So I think this dynamic spectrum sharing is beginning to work. And we see the fruits of that. So I wanted to highlight that. So with that, that was the main points I wanted to make. And I really appreciate being here. Thanks.

[00:11:06.79] CHRIS ANDERSON: Sure. Thank you. That was a great introduction. Jessica, your thoughts.

[00:11:11.75] JESSICA HEIM: So just a few intro ideas I wanted to throw out there. So I'm a PhD candidate and adjunct research fellow at the University of Southern Queensland. But I'm based in Minnesota, as I'm doing most of my work remotely.

[00:11:25.28] In addition, I've been a part of the American Astronomical Society's Committee for the Protection of Astronomy and the Space Environment, or COMPASSE, for several years. And I also co-lead the Community Engagement Hub of the International Astronomical Union's Center for the Protection of the dark and quiet sky from satellite constellation interference, which is thankfully abbreviated IAU CPS.

[00:11:45.87] I have an interdisciplinary background involving environmental science and the humanities, as well as both scientific and cultural aspects of astronomy. My research focuses on effects of human activities on both Earth and space environment, and delves into the complex relationships that humans have with both the skies above and the land below.

[00:12:05.13] The multifaceted nature of dark sky and space sustainability issues is such that they cannot be understood solely through any single disciplinary lens. It is essential to consider not only the technical, economic, scientific, and legal components, but also to recognize that there are broader considerations as well.

[00:12:22.20] When I was invited to speak at this event, I was asked to discuss ethical and cultural aspects of dark sky issues. As I also have a background engaging with Indigenous scholars and Indigenous perspectives on these issues, I was also asked to talk about dark sky matters in this context. Well, every community is unique and has their own perspectives. One commonality across many Indigenous communities is the fact that the stars and the night sky play a very important role in their knowledge, systems, and teachings.

[00:12:47.99] Also, many tribal nations are in locations that are remote and not currently well-served by broadband internet access. The advent of internet service, brought about by large satellite constellation, is often seen as a good way to bridge the digital divide and to enable access to broadband in rural communities in Tribal

Nations. And indeed, some tribes have utilized such satellite internet to better enable access to telehealth and other useful services.

[00:13:12.17] But the issue of internet connectivity is much more complex than simply creating a technology and then selling it to customers. There are many additional important questions to ask, such as does the price the service is being offered for match the price that those who could use such a service are actually able to pay? Also, who owns the service? And have those who stand to be affected by unintentional adverse consequences, such as changes to the night sky, been consulted prior to the deployment of the service?

[00:13:37.66] Sovereignty is an area of central importance to Indigenous nations, but this is, unfortunately, something that is often overlooked by well-intentioned individuals coming from outside these communities. There's a long history of outsiders coming in to help communities with pre-made solutions, rather than working collaboratively to find out what the community's needs and concerns are, and then working as equals to jointly create something of mutual value.

[00:14:01.33] In my conversations with Indigenous colleagues, one key theme that continually comes up is the importance of relationships. In that, if you are seeking to have meaningful discussions with these communities, whether it be about internet access, the importance of dark skies, or any other subjects, the most important thing to think about is the quality and nature of your relationships.

[00:14:19.54] In addition to the importance of building good relationships with people and communities, there are further relationships to think about when we consider the subject of space sustainability more broadly. We might ask ourselves, what is the nature of our relationships, not only with each other as humans, but also with the Earth, the night sky, and the larger space environment?

[00:14:37.64] To conclude, I offer that space sustainability ought not to be limited to topics such as reduction of and avoidance of space debris, and of the protection of dark and quiet skies. It must also include consideration of how growth in space activities stands to impact the continuum of Earth, night sky, and space environments.

[00:14:55.10] To truly be sustainable, it is important to consider the social and environmental impacts of the full life cycle of space activities, from manufacture, to launch, to the operational phase of missions through end of life disposal. By thinking in such a holistic manner, achieving long-term sustainability becomes more feasible, and novel solutions can be found. I look forward to the rest of the panel, and continue to discuss this with everyone.

[00:15:20.70] CHRIS ANDERSON: Thank you, Jessica. Kelsey.

[00:15:24.10] KELSEY JOHNSON: Good morning. Just by way of background, I want to share that I've been serving on the committee for radio frequency at the National Academy for the last six years, about to rotate off that. And also, just finished my term recently as president of the American Astronomical Society. So I've embedded been embedded in these policy issues pretty deeply for a long time, even though I bring my astronomer sensibilities to the table.

[00:15:49.56] So I realized that many of you are actually playing multi-dimensional chess here in terms of policy. And I'm coming to the table with tic-tac-toe, not even checkers. And really, all I have-- all I'm armed with are my astronomer sensibilities. And so I hope you'll forgive me for my naivete on some of these issues, and maybe indulge me for a few minutes as I wax a little bit, maybe philosophically, from my own perspective.

[00:16:18.00] I do want to say that, as someone who works at a public institution, I need to be clear that these are my own positions, just as Ashley is here in her own personal capacity. These are things we have to be careful of in the public sphere.

[00:16:32.24] So as an astrophysicist, I spend a lot of time thinking about humanity's place in the universe. I don't think most people understand how small we are on the scale of things. Thanks to Brad for the little analogy with the sun. But I don't think most people understand how small we are, both in time, and in space, and in the grand cosmic story.

[00:16:57.62] So I take a very long view. I find myself thinking daily, what will generations from now-- what will our descendants think about the decisions we're making today? And the discussions yesterday, it struck me. I don't know if it struck any of you this way-- that we all seem to hold-- or I perceive that we all seem to hold very different versions of what might be utopia. And I will admit, I may be the odd one out, which is often the case for me. So I just own that and lean into it.

[00:17:30.13] I do wonder, has anyone watched The Expanse? Oh, you all lost your nerd cred right there. I no longer take any of you seriously. Well, this may fall flat if you haven't watched it. I tried to watch it, and I had to stop. Not because it was bad, but because it was too accurate. And a version of The Expanse is actually where I fear that we're heading. So if that's not a spoiler for watching that and making you feel inspired, there you have it.

[00:18:03.06] I think it's fundamentally important, in these conversations, that we need to be honest and transparent about what we value and why we value it. If we can do that transparently and respectfully, I think we might be able to find even more common ground than we expect.

[00:18:20.49] But when we parse things through an ethical lens-- and I say this as an academic who thinks about things like this-- what that

requires us to ask is, what good is done and to what or whom? And what harm is done, and to what or whom? Especially in the long-term and on balance, which one wins out? If we're not asking those questions regularly, we are not acting responsibly.

[00:18:50.47] Now, it probably won't shock you that in my own value system, one of the most important things for me is-- and one of the most important things I believe we can do in humans, in our very small window of time on Earth, is understand our place in the universe. That journey begins with the night sky.

[00:19:07.93] And since before recorded history, the night sky has been a common touchstone for humanity. It has inspired wonder, navigation, storytelling, science, and the list goes on. Astronomers have been watching humanity's access to the universe erode, and that rate of erosion is rapidly accelerating.

[00:19:30.30] I believe that on the trajectory we are headed, that within a generation, the night sky will be cut off from all of humanity, no matter where you are on the globe. And I think that is the tragedy of the commons unfolding over our very heads.

[00:19:43.80] Now, I want to swap hats for just a hot second because I do also have an appointment in religious studies, and put that hat on for a little bit of a micro-lesson. Much of our current framework for thinking about outer space is actually embedded in religion. And I think many people don't necessarily realize that. It's rooted in a papal decree from the 1400s called the Doctrine of Discovery.

[00:20:07.20] In 1493, it was Pope Alexander VI, who issued a decree that justified European claims over non-Christian lands. The logic used in this decree was then embedded in Western colonialism, and the same logic today is showing up when people and actors assert rights to outer space resources, simply because they have the ability and the resources to get there first.

[00:20:32.18] Although, not a legal scholar, but if we were to lean on the legal framework like first appropriation-- and I don't think this would ever hold up in court-- but I would argue the night sky should surely belong to astronomy as the oldest science and predating recorded history.

[00:20:48.05] The reality of space is not a blank slate. And to be sure, it is rivalrous, and it is shared, and it is consequential for all of humanity. I would argue, we have to move on-- move beyond the inherited assumptions of dominance and entitlement, and instead, build a future grounded in equity, humility, and stewardship. Because without that, I truly fear that it will only be a few generations before we are living in the expanse. And I don't think anyone wants that. And just watch it if you need to.

[00:21:23.50] And finally, the last thing I want to share-- because this, for me, is one of my other core values, and I believe that most humans probably share this-- not everything of value can be owned, and not everything that matters can be measured in profit. And I'll end there.

[00:21:43.14] CHRIS ANDERSON: Thanks, Kelsey. Zack, can you share with the panel?

[00:21:48.97] ZACK DONOHEW: Thanks, Chris. I'm going to come approach this issue from an economics perspective, which you were leaning into at the end there, Kelsey.

[00:21:56.28] KELSEY JOHNSON: A little bit.

[00:21:57.05] ZACK DONOHEW: I mean, yesterday, we heard Patty talk about what a wet blanket engineers are at dinner parties. So let me see if I can convince her maybe the economist are instead. So I just walk through an economic way of approaching this dark and quiet skies issue.

[00:22:12.01] So there are no solutions. There are only trade-offs here. And the reason I say that-- because we're talking about a commons or an open access issue, and I would describe these problems as externalities. Satellite operators-- people are not doing things maliciously, but their actions for their private benefit are having spillover effects on third parties. And so while they get to accrue all the benefits, the costs of their actions, some of them are external to their decision-making.

[00:22:48.75] And if we were to stop them from doing that, then they would say, well, we would be harmed then by not being able to do our operations. And so in this sense, externalities are reciprocal. And it comes from a lack of well-defined property rights. Maybe we do want to a first come, first serve. The astronomers were here first.

[00:23:09.15] KELSEY JOHNSON: Hell, yes.

[00:23:10.14] ZACK DONOHEW: You should have property rights to it. If someone wants to interfere with that, they should have to buy those rights from you. Well, it is society's responsibility to decide how we do assign those types of rights. And right now, it seems to be just a de facto way.

[00:23:28.20] And so, economics is this-- as Caroline and Jennifer said yesterday, is the study and management of scarce resources. And so 10 years ago, this was much less of a problem because there was just a little bit less scarcity, a little bit less of an externality issue. Increasingly, this is a bigger issue.

[00:23:49.54] So from my perspective-- and maybe we'll talk about it a little bit later in the panel-- is that it would be great if we could get a better understanding of a number, if we could assign a number to what kind of values we're getting from dark and quiet skies. Because when

we can do that, then we can start to measure what that harm is, and then we can start measuring, well, what is the cost of that harm versus what might the cost of mitigation be?

[00:24:14.59] David mentioned earlier that Starlink are doing things to mitigate their effects, which is coming at a cost to Starlink, either in loss of service and coverage for a little bit or dimming their satellites. And so we can start to see what would be a really nice policy solution to this problem.

[00:24:34.07] But it's also been talked about. This is a global problem. And as we might expect-- or we could ask-- the United States to be best actors to take certain actions to limit these externalities that we're creating. But this is also a global problem, which acts as another layer to this issue. But it doesn't mean we can't lead by example and perhaps set some norms. So I'm really happy to be on this panel, and look forward to discussing this some more. Thank you.

[00:25:07.25] CHRIS ANDERSON: Great. And Paul, do you want to finish this off?

[00:25:10.39] PAUL KOLODZY: Well, I'll try. First of all, thanks for inviting me onto the panel. I mean, I think the last couple-- well, last two days here, actually having a group that comes from the policy side, as well as the technical side, as well as the economic side. Also, from academia, from industry, and from government. It's an interesting mixture that you actually can put things all together, and try to actually understand each of these perspectives and how we can actually address issues.

[00:25:38.98] Now, I'm going to come in from the technology side because that's what I know. So I'll let the policy people talk and teach me-- and the economics people to teach me new things. But from an engineering point of view, we like to solve problems. That's what engineers do. You give us a problem, and we try to figure out how to solve it.

[00:26:01.12] Most of the time, we're talking about-- in the sense of-- the topic for this conference has been resource management. We have a resource that is finite. And the question is, how do we manage it? I actually take a different perspective to this. I think it is resource management, but I actually think the real problem is entropy.

[00:26:19.37] And in some sense, I'll do a shout out right away to Ashley because she actually brought up this in some respects. Not all interference or not all interventions are random. If you actually know where you're trying to sense or you're trying to transmit, then that lack of randomness gives you an opportunity to solve the problem.

[00:26:40.97] And so the shout-out is there, is how you actually work with SpaceX to try to actually solve that problem by using reducing entropy. Not making it a random act anymore, and actually trying to

figure out how to exploit that. So let me go at how entropy actually plays into this a little bit.

[00:26:57.23] When a resource is brand new, and there's lots of it, you don't think there's much that you can harm-- you'll basically love entropy. Back in the 1960s, when we did launches, we had explosive bolts on the spacecraft. Boom! Bolt went off. Why? There's lots of space here. Lots of randomness here. Not much in there. So why not? That can harm anybody. Just adding a little bit of noise to the system.

[00:27:26.16] And then as time goes on, and using that resource, the noise builds up. Now, entropy becomes a problem. Because now, you can't get rid of it easily because it's random. If it was less random, you might be able to take it-- have techniques, as an engineer would, try to find a solution to taking out this randomness, and here's something that isn't random. You can actually try to remove it, or avoid it, or all the different techniques that you might want to use.

[00:27:56.68] And SpaceX is actually doing that right now because when they do their launches, they try to make sure there's not this random noise going out there meeting random bolts and whatever. Everybody's now trying to figure out a way of actually collapsing that entropy, and trying to make it that you actually can do something about it.

[00:28:15.83] And so in my opinion, that's what we want to do. We want to basically turn entropy into signals. And signals, in some sense, and non-randomness has a chance of actually solving the problem. And I think there's a variety of engineering tools that we might be able to do to actually try to motivate some of this.

[00:28:35.22] One of them, again, is-- I just talked about before-- is in the object space. In the actual physical space, you want to simply try to find ways to try not to throw out small particles, but larger clumps that might be able to be reused, that can be de-orbited, that can be used in other ways. In the RF, you want to have tight beams. You want to have low emissions. You want to keep things close in. So that way, that others will know that there's not a randomness in the sense of intervention.

[00:29:04.40] In the optical-- this is an interesting one. And I was looking at this a little bit over the last few weeks, actually. Ashley, through a conversation we had at one point, actually brought this to my mind, which is we thought that maybe diffuse reflectors are good. But diffuse reflectors are random. Specular reflectors are not random.

[00:29:25.27] So if you actually knew when you were get a reflection or get signal, you might be able to do something about it. I'm not saying it's going to solve all problems, but at least gives you an opportunity to solve those problems.

[00:29:36.21] And so what I'm trying to wonder about-- and this is, again, for the whole community to get together-- is, how do you set up the proper incentives to push to reduce entropy, to enable cooperation, and to enable more efficient use of it?

[00:29:51.72] At Logos, we're trying to actually look into some of this. And we're trying to actually look at how we can actually enable synchronization between the satellites at a high way, at a very, very precise way. Why? Maybe cooperation, in a sense of using basically distributed apertures for the astronomy community and things like this, may actually take this randomness behavior of all these satellites working individually, and try to bring them together in a coherent way, which, again, removes entropy. Thank you.

[00:30:26.86] CHRIS ANDERSON: Thank you. So that's a great lead in to maybe kick off discussion for the panel. So the panel has expressed the need for preserving a dark and quiet sky for a variety of reasons. We've talked about-- over the course of two days here, about the desire for connectivity, and satellites, and the utility of space and satellite coverage.

[00:30:58.10] And so as a way of thinking about these two in conjunction, what are the key technology, environmental, and economic challenges associated with preserving the dark and quiet skies amid the growth of these commercial satellite operations, both of which we've seen, over the course of the couple of days, have economic and non-economic value? So who wants to kick us off.

[00:31:28.17] ASHLEY VANDERLEY: Just very quickly, I like what Commissioner Gomez said yesterday, that one of the challenges was failure to ask questions. And we have found that when there is a discussion and people are engaging and asking questions, then the issues can be brought to the surface to find out, is there a solution? Because I think it's not all trade-offs. In some cases, there are solutions. But then on occasion, there will have to be trade-offs.

[00:31:52.43] So I do think that failure to ask questions-- so having the environments like this very conference and continuing that, so that we have a chance to share with each other, and make sure that we can ask the appropriate questions, and share with each other. But I think that is a big challenge.

[00:32:08.70] There's a lot of companies that come to NSF, for example, because they're required to coordinate. But then there's lots that have no requirement, but there's still things that they could do. So yet, how do you have those conversations? How do you ask questions? I think that's a big challenge.

[00:32:25.44] CHRIS ANDERSON: And NSF is National Science Foundation, for those that aren't aware.

[00:32:31.74] KELSEY JOHNSON: I'll jump in with a few comments on this as well. First, I do want to say that I don't think all space companies are looking to destroy access to the universe. That would be like a James Bond level villain, kind of, thing to do. I think most people are trying to act responsibly, and they're just not maybe asking the right questions.

[00:32:50.12] From my perspective there, there are really two things that I want to call upon folks in the satellite industry to really be considering strongly. The first is with respect to radio emission. All the things that have already been said. Astronomers, we are trying to be good partners. We recognize-- we're trying to find compromises where we can.

[00:33:11.38] One of the things we're trying to do is like, well, we have, right now at least-- maybe not for long-- we have a radio quiet zone right around the Green Bank Observatory, which is our way of saying, OK, at least give us access to this patch of the sky. So there's real importance, I think, to having radio quiet zones, which then enable all the things you want to send down to Earth and other places. Because most humans that I'm aware of don't actually see radio light, so it doesn't interfere with most humans.

[00:33:38.26] And I know Ashley's been working a lot on radio dynamic zones. So that the more predictability we have, the less randomness we have, the more we can work on what to do with the telescopes if we can coordinate. And so that's the radio perspective.

[00:33:53.83] From the optical perspective, this is harder because we really do need the satellites. I don't know if you all speak like optical magnitudes in astronomy. For reference, as Ashley said, the typical human eye can see between six and seven magnitudes if you're looking out at stars, which is roughly-- the North Star is a little bit brighter than that.

[00:34:17.42] But to date, folks in the satellite industry have really not been able to get the reflected brightness of satellites lower than that. Most satellites, to date, are brighter than the North Star when they're reflecting sunlight. And so that is a real serious issue, not just for observatories.

[00:34:36.26] And Rubin just came online. It's going to be a massive problem for Rubin. But actually, for humanity. In the sense that I don't know-- this is one of those things. If I asked you, how many stars do you think you can see in the night sky? And people would say, millions. Wrong. It's actually about 8,000, depending on your vision. It's not really that many.

[00:34:54.54] And so when you think about the number of satellites that are being launched and predicted to be launched, and that when they're reflecting sunlight, they will be brighter than the North Star, it won't be long before we have more satellites in orbit by an order of

magnitude than visible stars. And so we really, really need-- my plea for industry is to double down on your efforts for how we can make the satellites darker and reflect less light.

[00:35:19.61] And the problem is, it's not just optical light which humans see, but then many of the mitigation strategies. If we damp down the optical light, then they start radiating infrared light. And then we have another problem. And so we just keep kicking the can down the road. But the extent to which we can partner with you on that and work on getting the satellites fainter will help all of this. And we'll stop being squeaky wheels and complaining at all of your meetings.

[00:35:42.76] CHRIS ANDERSON: Paul.

[00:35:44.14] PAUL KOLODZY: Going down that path-- and I like what you were just saying, Kelsey. When a resource starts getting used-- when you have this collision of different groups trying to use it-- it's the time now, like with this kind of group getting together, is to start figuring out a common language and starting to learn about each other. So it's the collaboration before you try to launch-- before you try to do something else out there. And so it's always a good way to actually start.

[00:36:10.87] I was just reading some of the papers, and even the language that we use is different. It doesn't-- there's no right or wrong. But it's actually getting the communities together and start talking about what are the challenges that they're having and what might help each other? Versus one community telling the other community how they're going to solve their problem. It might be useful to collaborate, to discover what is the mechanisms to actually try to help each other?

[00:36:36.17] And again, that's why I applaud what this community is trying to do. This is the first time of trying to bring them together and start talking about it. I mean, just as an example, I was reading some of the papers. Of course, everything is done in janskys.

[00:36:46.86] ASHLEY VANDERLEY: Sorry.

[00:36:47.72] PAUL KOLODZY: No, no. You were-- as you said, you were there first. Is that jansky is a real term. And I looked it up, and I started looking at translation into the terms that I'm used to. That's just the first step. I mean, once you start getting a common language, then you have a mechanism to actually start trying to figure out what are the chances of how-- there's some techniques that we know about. There's some techniques that you know about. And how do you actually bring those techniques together?

[00:37:14.56] KELSEY JOHNSON: Chris, do you want to share your little factoid about how sensitive radio astronomers are?

[00:37:18.63] CHRIS ANDERSON: Yeah. So this comes up frequently. So I've been working with Ashley in the National Radio Dynamic Zone effort. And the translation is a little bit wonky because jansky is a power

density. It's watts per hertz per square meter. So you have to make some assumptions about the size of your antenna and your bandwidth, and things like that.

[00:37:40.11] But as a back of the envelope engineering calculation, a radio astronomy telescope, so something like the VLA, the Very Large Array or the Green Bank Telescope, can measure or record a signal at about negative 300 dBm. For most of us in the commercial world of Wi-Fi and cellular signals, a strong cellular signal is about negative 80. A strong Wi-Fi signal is about negative 80 dBm.

[00:38:12.39] So you think about, it's a logarithmic scale, so it's many orders of magnitude more sensitive than what most people are used to with a Wi-Fi device and with a cellular phone. Again, caveat that with-- there's a lot of assumptions that go into that negative 300 dBm number. But roughly speaking, when a radio astronomer says, I can see a-- I can measure a cell phone signal on Pluto, yes, they can.

[00:38:47.50] Well, let me-- this has hopefully stimulated some great thoughts in some folks in our audience. And let me ask if there's any audience questions that we want to kick off the panel discussion with. And I see a student right here ready to go.

[00:39:07.87] Hi. My name is Jack [? Cashin. ?] I'm going to be a fifth-year aerospace engineering undergrad. I grew up in a pretty rural place in Colorado Steamboat. And I could drive five minutes by my house and go look at the night sky. And I have pictures that I've taken from that, if you want to see those. It's like asking pictures of your baby.

[00:39:33.46] So astronomy, for me, was a huge, important part of why I got into aerospace. I'm getting an astrophysics minor. I have a tattoo of a constellation on my body. That's how much I care about it. But-- I just looked this up-- according to the CIA, 83% of people live in urban areas.

[00:39:53.27] And how do we get people who don't have access to the night sky more because of, I guess, light pollution, which isn't really what this is about, caring and understanding why having some dark and quiet skies is really important?

[00:40:07.44] Because you mentioned the GPS issue. And it's like-- you mentioned yesterday the, oh, I don't need GPS. I have an app. And it's like that app uses GPS. Please inform yourself. But how do we get more people to understand, especially now that their general night sky usage is blocked off from light pollution?

[00:40:26.41] JESSICA HEIM: I can start with that because I have a background with ground-based light pollution issues as well. What you're describing is a major issue. And just like talking to so many people telling me stories about, oh, when I was a kid, this is the dark sky. And even my own personal experience in my lifetime, seeing the impacts of ground-based light pollution, it's a huge issue.

[00:40:46.64] And I did some research, looking at DarkSky Advocates and how they were able to successfully get in better lighting. So for everyone to keep in mind, we don't necessarily have to be creating so much light pollution. We could light our cities, and we wouldn't have to lose the beautiful view of the universe. It wouldn't look like the middle of the wilderness when you're in downtown New York City, but it doesn't have to be as bad as it is.

[00:41:11.39] But I think that is a challenge, is getting that-- that personal connection, I think, is really important. I used to do work in a planetarium, and we would simulate what the night sky looked like. And we'd have these third graders, and they'd come in and they'd be like, Wow! They had never seen what that looked like in real life.

[00:41:29.36] And I've talked to people who had gone to a planetarium, and they're like, Oh, I thought that was made up until I went out to a rural area. And I've just heard so many stories of people who describe this emotional experience they had with the night sky, and that inspired them to go into engineering or science, or not necessarily astronomy, but some other science or space field.

[00:41:46.33] And I guess my personal thought on that is just it's really important to design our ground-based lighting better so people do have access to that. Because I think it is difficult for people to connect to something that they don't have personal experience with. It's like a quote from a book-- I can't remember the author right now. But he was like, How do you get people to be concerned about a forest if they've never seen a tree?

[00:42:10.36] And so I think that that's an important part of science education, K to 12-- giving people opportunities to be able to have some degree of experience with that, or people aren't going to care about something that's just abstract.

[00:42:23.47] KELSEY JOHNSON: I want to-- Jack, if I can jump in here. First, I admire your commitments with the tattoo. I'm looking to get Euler's equation myself. I mean, I think this is-- wow, that got more laughter than I ever thought it would. Maybe I should get it before I leave on my flight. I know. Maxwell-- I've seen people with Maxwell's equations, and that is commitment. So that [INAUDIBLE], Jack.

[00:42:51.79] So I founded a program called Dark Skies, Bright Kids like 15 years ago with, actually, this very mission. And I wrote a book called Constellations For Kids with this very mission. And I think the real problem is people don't know what they're missing if they've never seen it. And so I think it's incumbent. We do everything we can, as astronomers, to try to get the voice out. But we're like-- I don't know what small percentage of the population.

[00:43:14.32] We really need it amplified by other people who are not us. We need you to go and do dark sky tourism. If you've never actually seen a truly dark night sky, that is your homework assignment. And I'm

a professor, so I get to give that to you. You need to go see a truly dark night sky to understand what humanity is losing access to.

[00:43:32.96] You need to take your kids, or your grandkids, or your neighbor's kids, or kidnap some kids off the street-- I don't even care-- and bring them to a dark sky location so they've seen it at least once in their life before it disappears. Because if people never see it-- this is exactly your point-- they don't know what they're missing.

[00:43:49.24] ZACK DONOHEW: Let me approach Jack's question from quiet sky's perspective. How do you get the public to care? And there's some market-based ways that this happens. We heard from Ms. McGrath yesterday, talking about the loss of data quality. And so if we're a little less precise in forecasting hurricanes, if we're a little less precise in our irrigation scheduling-- well, those things have value. And insurance markets do a really good job of incorporating those risks.

[00:44:19.03] And so if they don't have as good enough-- good quality, then they're going to-- those models aren't going to work as well. And you're going to see that reflected in the prices of things like insurance. And so everyone will be affected by that, whether they connect the dots between those higher insurance prices and a reduction in data quality. Maybe not. But the market is thinking about these things.

[00:44:42.38] CHRIS ANDERSON: Anybody else? I see another question. I saw this hand go first.

[00:44:48.77] AUDIENCE: I'll be quick. I'm, on occasion, offshore sailor, and I always volunteer for the midnight to 4:00 AM just for that. I do want to make a comment on Zack. Not everything is really ability to price intellectual property. It's just not. I mean, a lot of art is really priceless.

[00:45:12.29] So when you look at future-- well, you want to call it entropy or not-- future cloudiness for the radio telescopes and optical telescopes, you're preventing future knowledge. It's like, how do we acquire future knowledge? And how would we price future feature knowledge that we don't even know?

[00:45:35.95] So certainly-- I'm a commercial space guy, so I get it. And we're on the weather side, so I get that. I mean, the precision knowledge of this atmosphere of this planet-- because we're an under-sampled system right now to be able to do better forecasting and better knowledge of climate research.

[00:45:58.42] The comment that I'm just making is, I'm agreeing with Kelsey-- for not to be good denizens of space across the board. And you can't really price everything, and you're just not going to happen. And certainly, I agree with Ashley on-- oh, my God, those pictures are great. So you really, really have to see it. And it puts things in perspective, the human perspective.

[00:46:24.67] And back to Kelsey on the 1400s, or so. It's really before that. Certainly, Joseph Campbell, and the myth, and the skies, and the gods. And hey, it's wondrous. So I just have a hard time bringing it down to economics because it's just not. And I know you that wasn't your push. But I just wanted to make that as a comment than anything else.

[00:46:55.27] ZACK DONOHEW: I really appreciate that comment very much, and agree with you. And I thought-- Kelsey, I thought you were going to punch my arm when I said that. I was prepared for that. But--

[00:47:03.88] KELSEY JOHNSON: How else are we going to sell it to people if we don't try to put values on things? We have to try to. Otherwise, we can't even make a case. Because some things are priceless.

[00:47:13.37] ZACK DONOHEW: How you do trades.

[00:47:13.81] KELSEY JOHNSON: How do you trade something that's-- and sorry, I'm going to shut up.

[00:47:17.09] ZACK DONOHEW: No. I agree with that. And the other way is, I think, it's useful to try to get a lower bound attempt. Like what is the value of cultural heritage? Economists have some ways of trying to get that type of value. What is the value of dark skies tourism? Economists have studied that.

[00:47:36.61] I looked at a report the other day that showed, like, in the Colorado Plateau, it's about $2.5 billion per year. So we can start to-- OK, well, that's a value, then-- really, a lower-bound value. Then we can think about what the costs of that are. How much less tourism are we going to get if the skies aren't as dark?

[00:47:56.16] So how can that help us, though? It's not everything. But how can it help us make a policy decision? Well, we could make a policy decision that we're going to tax the size, or an approximation of the cost that operators are imposing on society writ large. Maybe that goes into higher user fees or some bond that could be rebated based on best practices.

[00:48:25.63] And we can-- so that we can look at, Oh, here was the value. Here's what the cost of doing nothing is. And so then we can start to price what that externality is, and internalize-- make operators internalize their decisions. And maybe they'll attenuate the amount of pollution they're creating. Or otherwise, we can use that revenue to help dark and quiet skies initiatives. So I agree with you. It's not everything, but it at least helps us make better policy choices.

[00:48:56.11] ASHLEY VANDERLEY: I wanted to add in real briefly that there is a real cost to mitigations. And I think one frustration in the satellite industry is that it's not clear what mitigations will, quote, unquote, "solve the problem." So this is one thing astronomers are trying to work towards.

[00:49:10.89] Tony Tyson, who's the chief project scientist for Rubin, is actually hosting a workshop later this summer, looking at that question-- how many satellites is too many? Because if you have a constellation with only two satellites or one, like the International Space Station, astronomers can simply track where it is in the sky and make sure they don't point at it. But when you get enough satellites, where no matter where you point, there's always one that bright, now you have a problem.

[00:49:34.65] And so there's actually are some quantified questions that have not been answered by the astronomers. There's a lot of work that can be done. And so I think knowing that there's a real cost, especially to small startups, as David Goldman was talking about, it's not something that every small startup can do. And so I think that's where it's going to be helpful, is we can work together towards identifying what mitigations and steps really make sense.

[00:49:59.65] And then, are there ways that we can pool our resources to all help each other so that every company doesn't have to go and reinvent the wheel with a particular innovation? And if it's a small enough constellation, for example, maybe the only mitigation is that high-precision telemetry needs to be provided so astronomers can point around it.

[00:50:16.09] But then, when there's larger constellations, that's when it's more important that the darkness doesn't exceed a certain amount if it's going to be everywhere-- ubiquitous. So yeah, I just wanted to point out-- I mean, that's a very real problem and, I think, a frustration among the satellite industry that we do need to keep working together on.

[00:50:33.50] CHRIS ANDERSON: Great. So I got a question up here. And just a reminder, if you could please state name and affiliations of this guy right here.

[00:50:48.62] AUDIENCE: Hi, again. My name is Andreas. I'm a fourth year aerospace student here. I wanted to hear a little bit more about the telescope boresight avoidance. I was wondering, how applicable is that to the many satellites that are already up there? And then also, is that a voluntary thing right now? And do you foresee that becoming like a regulatory requirement, either nationally or internationally?

[00:51:19.84] ASHLEY VANDERLEY: That's a great question. So there's a number of papers-- I'm happy to point you to it in the break-- that are actually described in great detail. But essentially, the boresight avoidance works, where the telescope-- and its different depending on the field of view of the telescope. There's an inner and an outer angle.

[00:51:35.66] So for the SpaceX satellites, when the transmission gets within that inner boresight, they actually turn off their transmission. When it's in the outer boresight, they actually just move the beams

away so that you don't have that conjunction. It currently is completely voluntary. So it's been just cooperation, which has been fantastic.

[00:51:55.84] And it's something that required software development at the telescopes because astronomers were used to doing their own thing. So having to provide the schedule in advance in a way that's secure, that a satellite operator can ingest. And so we're actually hosting a worldwide discussion on July 1st of what a standard format would be if other observatories wanted to participate in this technique.

[00:52:18.50] But there's a number of papers that have explored in how well it's working. There's still some challenges and technical things to be worked out, but it has drastically improved the interference situation for telescopes.

[00:52:32.97] CHRIS ANDERSON: I see a guy up here in the front. You guys on this side of the room are going to have to start asking questions at some point. He's up there.

[00:52:48.90] AUDIENCE: Hey, I'm Dan Baker from the University of Colorado. First, it's encouraging to see people from very different walks of life, so to speak, speaking collegially and civilly with one another. I hadn't necessarily expected that.

[00:53:04.94] But yesterday, one of the panelists pointed out that the ozone hole problem was dealt with. And I think a reason was an economic one, Zack, and was that there were other chemicals that could take the place of the fluorocarbons for cooling systems. And so there was money to be made. I think we're seeing that there's money to be made in the service providers, but I think there's money to be made on the other side, too, to have better surface materials on satellites to reduce interference.

[00:53:49.66] We heard about some ideas to reduce the number of launches, perhaps, by having refueling. There's money to be made, perhaps, in debris removal. And so I don't want to go through all the economics. You guys can do that better than me. But I think we have to start to have more attention to what is the proposition-- what's the value proposition for making the situation better, and not just allowing it to be driven by the service provider money? So I'd welcome comments from the panel.

[00:54:30.18] KELSEY JOHNSON: I'm going to jump in without-- I agree that we need to have these value propositions. And I'm not the person to make them, as is clearly abundantly obvious to everyone. You reminded me of something, though, that I really wanted to share because I don't know if everyone is aware of this. You're talking about the ozone. I know, Dan, you're aware of this.

[00:54:47.93] When we're looking at-- which I think we can all agree in the near-term, 50,000 satellites in orbit is not a pipe dream. That's happening probably pretty soon. When we look at the re-entry rates

for those and we make some assumptions about what those satellites are made of and the elements they're made of, ballpark-- and I'm an astronomer, so I do a lot of ballpark estimating.

[00:55:09.50] Ballpark, we're looking at about 100-- about 1,000 tons of aluminum vaporized in the upper atmosphere every year. Right now, it's not really a big issue. Because right now, the amount of aluminum vaporized in the upper atmosphere is actually-- it's not that different from what we naturally get from meteorites. And so at the moment, it's not raise the alarm bells panic.

[00:55:28.87] But when we get up to 50,000 satellites in orbit, and presumably that number will go up, we're looking at significant amounts, orders of magnitude over the natural meteorite fraction, being vaporized in the upper atmosphere.

[00:55:43.21] And atmospheric scientists really have not had a chance to study this. We don't know what impact it's going to have. It could be catastrophic. We're doing inadvertent geoengineering here without thinking about the consequences. And so I do want to raise that as something I really hope folks in industry are thinking about. Because I don't think anyone here, I hope, wants to destroy the planet.

[00:56:04.62] JESSICA HEIM: Just a very brief follow-up on what Kelsey just said, that yeah, both launch and reentry at the scale of what's happening is having atmospheric impacts impact. And even something as benign as water vapor put at a level in the atmosphere, where that's not naturally there, does create changes in chemical composition. And we don't know the consequences of that. But we do know that there are changes happening. So it's something we really need to be aware of, and continue to think about.

[00:56:30.79] KELSEY JOHNSON: Can you speak to the value proposition?

[00:56:32.88] ZACK DONOHEW: I don't know. I mean, we have 20th century institutions for 21st century problems. And we need to update this greatly, particularly when if Starlink represents the great vast majority of current satellites in operation, but that's going to change. It's going to be-- internationally, that's going to change.

[00:56:54.21] So the ozone layer example is great because the Montreal Protocol was countries coming together to sign a treaty to avoid a very bad global outcome. And so that's what we are going to need, again, with this global commons problem. And so whether that is amending the Outer Space Treaty or approaching it from some other way, it's going to require that international cooperation. And a global understanding of what the value of taking action is, even if it is costly to firms and countries to do so.

[00:57:33.18] CHRIS ANDERSON: So we have time for one quick. And I see somebody that already has the microphone. So you got it. So I'll

say one quick question and brief stressing brief-- response from the panel.

[00:57:48.61] AUDIENCE: Short question. I appreciated the discussion about educating citizens about the value of dark skies-- night skies. What champions do you have? Do you have caucuses on the hill? Do you have policymakers that understand that? Do you have a radio astronomer that's actually a member of Congress? I don't know.

[00:58:10.76] I'm just curious. How do you activate the planetary science caucus? Because I know there's one in the house. I'll stop there. Could add more. But because that's the community that makes so many of the policies that implicate you or impact.

[00:58:28.43] ASHLEY VANDERLEY: So I'll just speak briefly. Lindsay DeMarchi, who is now at the Aerospace Corporation, had been working for Senator Hickenlooper's Office. And she had actually worked on some legislation that, I believe, was introduced in the last session to create a center for excellence to study more in-depth. So that was something that, I think, is still out there. I'm not aware of any more formalized caucus. But there are folks, especially on scientific committees that do ask questions and are interested in the topic.

[00:59:02.30] CHRIS ANDERSON: Anybody else?

[00:59:03.98] KELSEY JOHNSON: One thing I would-- I mean, I think the point you're making is really important. And as astronomers who are not naturally good at these things, it's hard for us to do this. Sometimes our hands are tied because of the institutions we're affiliated with. We have to be very careful in public institutions about what we can and can't do with respect to government. So that's just an issue we have to navigate as well.

[00:59:24.87] ASHLEY VANDERLEY: One other just quick comment. If folks are not aware, the United Nations Committee on the peaceful uses of outer space, Scientific and Technical Subcommittee, STSC, they do have a five-year agenda item that was passed and began in February of this year on dark and quiet skies. This was led by the government of Chile and Spain. So there will be that opportunity for international discussion, sharing best practices and things at that particular forum. So I did want to bring that to your attention if you were not aware.

[00:59:59.24] CHRIS ANDERSON: Well, if that's it. Thank-- let's thank our panelists.

[01:00:02.46] [APPLAUSE]

Panel: Beyond Earth | Extending Spectrum Management to Deep Space and the Moon

https://youtu.be/qpSl8xVODm8?si=3ZD3L9OEzQ9Uzflo

[00:00:01.23] DAVID REED: We're going to try to get started here. Let me try to get at least my panel under control here.

[00:00:08.19] [LAUGHTER]

[00:00:10.25] GERALD ADAMS: Good luck with that.

[00:00:11.55] DAVID REED: Yeah. Well, thank you very much for still being here at the conference. I think we've got a good closing panel for you to think further about these issues. Actually, we're divided into two basic areas of discussion. I've asked each panelist section of one who's joined us on last notice here, which we very much appreciate, to do a brief presentation. And we have something novel for this conference. We actually have some slides, all right? And so we'll go through and we'll comment on that in the first half.

[00:00:47.46] Second half, I have a few questions, where we're kind of hitting cleanup here on the conference topics and issues. So we're going to cover some of those. And then I'm going to turn it over to you for 15 minutes to raise some questions that you might have from the presentations, obviously, or from the conference in general that you would like to get some reaction from the panelists on. So that's the plan for this panel.

[00:01:18.75] I'm going to introduce my panel first here. And just going right down the line here, I've got Gerald Adams, who's the Sharswood Fellow and resident scholar with the Center for Technology, Innovation and Competition at the University of Pennsylvania, Carey Law School. We have Rob Frieden, the Academy and Emeritus Professor of Telecommunications and Law at Penn State University.

[00:01:43.75] We have Carolyn Kahn, who has been introduced before. But she's the Distinguished Chief Spectrum Economist at The MITRE Corporation. We have Lynna McGrath, who is the Deputy Associate Administrator for Spectrum Management within the NTIA Office of Spectrum Management, who is the one who subbed in on late notice. So she has the ability to say, hey, I didn't know I signed up for this, and pass. [CHUCKLES]

[00:02:12.76] And then we have Scott Pallo, who's the Charles Victor Schelke Endowed Professor in the Smead Department of Aerospace Engineering Sciences at CU, Boulder. So our final panel here, we're going to be digging a bit deeper into this notion of different frameworks for spectrum management and how they may need to differ between terrestrial and space communication systems.

[00:02:38.71] And we're going to investigate this from an interdisciplinary perspective, which is my favorite passion and preferred methodology for investigation. So I do have our anchor, so to speak. Dale Hatfield will recognize this. This is a framework. Dale and I teach a class on spectrum management every Maymester. And there's two fold for that.

[00:03:06.51] First is we get a lot of technical engineers who want to understand more about spectrum management. And the second is that we have Hatfield scholars from the law school who are going-- well, most of them-- to Washington to work at some of the areas that you might be interested in, places like the FCC or the NTIA. And those law school students, this is their first exposure to spectrum management.

[00:03:38.71] And so they are spun up, and they really hit the ground running. So I'm doing this, in part, to let you know that if you're interested in having law students or other Hatfield scholars, they don't have to be just legal, right, Dale? They can be technical. Talk to Sarah Schnitker and get on the list, because these students are really energetic and interested in the topic.

[00:04:06.54] And we have a three-week boot camp. And we're covering all topics spectrum management. And the feedback we get is they do hit the ground running. So part of what we cover with the students is to make sure they understand just the basics of spectrum management. And we have four fundamental steps here in what we call the spectrum management framework that we work through the course.

[00:04:33.00] And this framework came from Dale, Bryan Tramont, and others that have taught the course before I did. But we really try to stress these four fundamental steps. Hopefully, they look familiar to you for those who are experts. So I don't need to go through it and define each one of them. But at the top level, obviously spectrum allocation is just who gets particular bands. The technical and service rules are really the constraints that are put on it in terms of how it's used.

[00:05:03.48] The spectrum assignment, who gets it. And then the enforcement is-- without enforcement, what is steps one through three mean, right? And so I've asked the panelists some to be cognizant of these categories. Because sometimes within these conferences, you get statements that seem-- that converge various enforcement steps with Spectrum allocation decisions.

[00:05:28.00] And so I'm trying to use this as a way to help you as a tool to organize your thoughts about-- with all these problems or issues that we've covered here within this transition to more usage in space, this is a nice framework to help anchor you on what these different

issues imply. So we're going to start with Gerald. And I'll turn it over. Five minutes.

[00:05:53.58] GERALD ADAMS: All right. Thanks, David. So I think just to start, because we're batting cleanup here, just to recognize that this discussion is at least partially emblematic of a broader theme that's been brought forward throughout the last two days, which is-- this quote is coming from The Financial Times article back in March, essentially recognizing the commercial space age is here. Commercial filings for lunar spectrum in particular in the context that we're viewing has surpassed those of space agencies and governments.

[00:06:27.65] The figures themselves are a little bit misleading. This is showing cumulative filings. But nonetheless, if you look at the spikes themselves, we see fairly marked jump by commercial actors. And there's at least some projections that these spikes are going to get even more significant and it's going to continue throughout the foreseeable future, to the point where we're having hundreds of filings. And so the question is, OK, well, what do those filings actually entail? This is representative of the commercial Lunar Payload Services initiative that NASA is doing. So it's somewhat of a public-private partnership.

[00:07:04.35] Where exactly are these payloads being placed? I think for our folks on the radio astronomy side, the middle figure is probably slightly concerning. The one I want to emphasize is actually on the South Pole, where this is just providing an indication of commercial operators contracting through NASA.

[00:07:24.00] Has no discussion of the broader international actors that are also going to try to occupy and use the South Pole for various reasons. And so this is just a tiny sliver of what the actual occupancy and environment is going to look like.

[00:07:41.87] MAN: Gerald, you're muted.

[00:07:44.33] GERALD ADAMS: Am I quiet? Sure. Yeah, so the question is, OK, well, now that we're in this new arena, it's not necessarily a new problem. But it is a new environment for facing that problem. What do we need to do? And right now, the management regime is a Band-Aid is the way that I would phrase it, right? So my understanding is most of the operators that have put payloads out on the moon, they're operating under experimental licenses.

[00:08:15.03] I know-- maybe Jennifer will correct me-- I think you shot your shot for a blanket license. I don't know how that went. But nonetheless, it's not providing any sort of security of expectations here, right? If we have to continually ask for experimental licenses and waivers, that seems somewhat problematic. There's also the lack of allocations, at least in the bands that folks want to occupy. And so you have everybody operating under 4.4, where it's a non-interference basis.

[00:08:43.34] And so we want to try to provide some semblance of security. We want to have some sort of management framework. What does that entail? And I think it gets to the title of our panel, which is "extending," right? And there's been some at least arguments or proposals that we just take the terrestrial frame and extend it out into space. And so we look at the frequencies themselves. We already have space research frequencies. But nonetheless, they're probably insufficient.

[00:09:10.77] For commercial operators that want to economize on the antennas and the payloads that they have, it makes a lot of sense. The things they want to use for space-to-earth operations work for space-to-space operations. We're going to need some updated service rules based on the idiosyncrasies of the environment that it's operating in, right? The path loss environment is somewhat different. But nonetheless, we're kind of pulling the same moves that David recognized at the outset, right? We looked at allocation. We looked to assignment service rules.

[00:09:39.00] And we recognize that because this is use of space, and often satellite services, there's a degree of governance involved here, right? This is a shared spectrum, so there's some degree of registration, both domestically along with through the ITU, and then a degree of cooperation and coordination between the entities themselves. What I want to get to is a little bit more of the provocative point, which is that outlines governance.

[00:10:09.75] And I think we've done a good job of presenting governance over and over here. But it's a little bit of a hand-wavy thing to just say, we do governance, and governance occurs through the ITU. First come, first serve. You have priority, and just make nice with all the people that are ahead of you. I don't know if that necessarily provides the rigor that we're looking for here.

[00:10:32.93] And so just using the terrestrial frame as a foil here and looking to space, what we kind of run into and what I think is the problem from an academic perspective is on Earth, we kind of have the crutch of what I call [INAUDIBLE] proxies, which, really, what I'm saying is there's some moderate degree of exclusion that's available, which is on Earth, we do have sovereign boundaries.

[00:11:01.45] There is some degree of exclusion involved because the interference is happening at the receiver, that on a country by country basis, there is a little bit of leverage to come up with robust management regimes. And I look to even the US in particular, which is, yes, we have kind of this in-the-backdrop ITU coordination procedure and regime that's existing.

[00:11:22.75] But when people talk about satellite coordination, particularly on the fixed satellite services side, we're talking about the US's regime with the processing rounds and the entire framework for

spectrum sharing between systems within a processing round and between multiple processing rounds. That is the structure. That is the rigor of what governance actually looks like. But the first step of it is there has to be a defined boundary. And usually, that boundary has some degree of exclusion.

[00:11:51.64] I don't want to jump ahead of your question, David. But I mean, this is well known, right? This is the Elinor Ostrom frame. If you go through the eight requirements that she has for a common pool of resources and governing them, the very first step is clear boundaries, right? The first step is some degree of property on the outside, and then we do the commons on the inside.

[00:12:17.22] And so it provides some degree of what I'm saying is a gatekeeper, right, and an enforcement hook, the thing that we really need for governance. On the moon, we don't have that, right? For the orbits around the moon, we also don't have that. Article 2 is very candid and clear that we don't have appropriation or declarations of sovereignty on the moon. Post CogniSAT whoever brought that up yesterday-- in theory, we don't have that for orbits around celestial objects either.

[00:12:50.94] And so we're kind of missing-- I know a lot of people-- David Goldman probably isn't here anymore-- a lot of satellite operators complain that getting market access in countries is a just horrible pain and frustrating experience. And it's somewhat idiosyncratic. And it varies country by country. But it provides a crutch here. The borders are the crutch for our governance regime from Earth to space and space to Earth. And we don't have that in the lunar context. We don't have that in the cislunar context.

[00:13:21.63] And so we have to really come up with some sort of more robust, uniform governance regime that actually does the moves, rather than just saying we're going to coordinate and hope on best practices and good faith. Maybe I'm wrong. I just don't have a lot of faith that that's sufficient. And so what does that require? Well, it's going to require some degree of consensus. Our hope and dream is that it's something emblematic of multilateralism from the '60s and '70s. I'm not sure that's necessarily going to happen.

[00:13:56.63] I wish Cathy was here. But she essentially had said, well, we do pre-coordination. We have things like the space frequency coordination group. We have these procedures that exist. They're all based on an outdated regime, though, right? They're all baked on the idea that this is a few nation states engaging in coordination with one another. And that's no longer the world that we live in, which gets back to my first slide.

[00:14:21.63] We have a myriad of private actors with various interests that are operating under flags of multitudes of countries that need to have some sense of security of what coordination is going to look like,

what governance is going to look like, and whether there's any sort of security of expectation here. And that seems to be markedly lacking at the moment. So that's the work we should be looking towards. That's the thing we should be trying to fix.

[00:14:48.22] DAVID REED: I'll give you a couple extra minutes. You're on a roll.

[00:14:51.06] GERALD ADAMS: I'm sorry.

[00:14:51.81] DAVID REED: OK. [CHUCKLES] No, no. It's good. Any comments or reactions from, uh, um-- Yeah.

[00:15:00.12] CAROLYN KAHN: I mean, I'm just thinking with what you're saying with property rights and-- do we take space, which is very different like you pointed out to on Earth, and define property rights on space? Or maybe there's a new model, or the model needs to evolve to fit space.

[00:15:19.94] DAVID REED: Yeah. So I think property rights is one form of getting what I'm calling some sort of exclusionary baseline or boundary regime, right? That would be the traditional economist [INAUDIBLE] characterization of how we would go about and do this. I don't know. Maybe that's how we structure it, is we essentially establish some quasi entitlements on the moon or in the orbits around it and then assign folks to them. Or it's just providing a more robust procedure, where we're a little more rigid in who's let into the club and who's kept out of it in certain sequences. Yeah.

[00:16:03.61] LYNNA MCGRATH: So I'll dive back in on the spectrum management piece of it. When you started off and you said the commercial operators are all operating on an experimental basis, well, why is that? Well, let's go look at the US regime. Most of the time, they're operating in space research allocations. Historically, those have been federal. So you look at what those bands are, they're federal exclusive. So given our frequency management process here in the US, they're operating on an experimental basis.

[00:16:36.48] We're seeing that regime change. Space research is not just the purview of governments anymore. It's now becoming the purview of commercial industry. And do we need to look at changing that? And as you said, do we have enough space research allocations to support that? That's a question the ITU is looking to tackle. But then, whose spectrum do we take to do that in? And a lot of the times, when you see space research allocations, there's also a load of other allocations on there.

[00:17:12.19] So you've got all the other federal users doing other sorts of space-based activities or even terrestrial activities that we're trying to coordinate around. So we're looking at that. The world we knew, where this was the purview of governments, has moved to commercial industry. And then, yeah, you're very much right. How do

we change the regulations? We have to support the world we're dealing with today.

[00:17:35.29] DAVID REED: So, Lynna, the reason it's inflexibility is-- one observation. Is it fair to say it's because it's the most flexible framework that was available that allowed that to happen within-- it wasn't necessarily all experimental. It was mission based of things like that, right? But that's what was the path of least resistance.

[00:17:58.79] LYNNA MCGRATH: I think a lot of times, you're dealing with companies that are trying to use existing hardware which is optimized to operate in those bands. And please start-- I don't have my table of allocations in front of me.

[00:18:13.82] DAVID REED: [CHUCKLES]

[00:18:14.12] LYNNA MCGRATH: Would someone please find me the non-federal space research allocations? We don't have them. So we have innovative companies trying to do things, and we don't have regulations. And the current setup doesn't fit. So we're trying to fit the square peg into the round hole using the tools we have today.

[00:18:38.29] DAVID REED: OK, all right. So I have another question. And I'll touch back on this a little bit more. But this notion of the Commons is something that I think is a key economic characteristic that we haven't talked about so much in the conference so far. We've kind of said we need to have cooperation and things like that. So we'll circle back. Nate, can we get a black screen here for-- go ahead.

[00:19:07.65] ROB FRIEDEN: Thanks, David. I appreciate it. I've got lots of slides. And quite frankly, with the time available, one slide would take the entire time. But I encourage you to take a look at my website. Just research the name. And I've got a wealth of slides, particularly for your students. Speaking of slides, I want to shoutout to Dale. I've used his spectrum management slides for decades, with attribution. And the fact that I've been able to do that at least speaks to some of the sustainability of the structure.

[00:19:41.93] Now, I'm going to talk about how the structure is its own worst enemy in a way. But I do want to gently push back at a comment that was mentioned today that the ITU was, quote, "totally irrelevant." I'm going to push back on that and suggest that the ITU-- and let's add the United Nations-- is at risk of losing legitimacy. And that's already leading to the prospect and the advocacy for a sort of go-it-alone unilateralism. Some scholars have titled that or captioned that, framed that as polycentric governance.

[00:20:23.91] And we already can do some sort of a case study in the notion of polycentric governance or unilateralism. And that case study would be on the Artemis Accord, which, quite frankly, in conjunction with a subsequent executive order, disassociates the United States officially with the 1979 Moon Agreement, an agreement that, quite

frankly, has failed-- 1979-- and has only about 18 accessions, national accessions.

[00:20:57.39] The US government officially disassociates with the concept of shared commons, particularly insofar as asteroid prospecting, extraction of resources, and colonization of celestial objects. And that is creating pressure-- yet more pressure on the ITU process and the UN process that has as a baseline consensus view of a shared commons-- going to your comment about shared commons. Let me suggest this. Let me present you with a worst-case scenario, OK?

[00:21:32.67] And not to disparage anybody-- and I certainly don't want to be flamed on social media by suggesting that space advocacy, which, by the way, I had a slide showing Messrs. Musk and Bezos having at it in the court of public opinion and social media, sort of working the refs, in this case, working the FCC refs. But arguably, a worst-case scenario would be that private ventures ascribing to the move fast and break things credo have lost patience, have lost trust in the status quo, in the ITU process, in the UN process.

[00:22:15.83] And they move forward unilaterally, or they create ad-hoc affiliations. They have a polycentric view of the world. Let me give you two examples where maybe that wasn't a good idea. Maybe that model isn't so robust and sustainable and something we want to embrace. In 2008, the FCC fined a company called Swarm $900,000, which was chump change to this startup venture-- which, by the way, then sold itself for $524 million to SpaceX-- for forgetting to secure launch authority for CubeSats, small satellites.

[00:23:04.63] I mean, these things happen, right? Well, there is something to be said for a process where you advance publish your frequency use, advance publish your orbital slot use, advance publish your orbital plane use, put people on notice that that's where you want to be, and engage in coordination. It's a slow process. It's an incremental process. It highlights a four-year cycle through world radio conferences for spectrum management, which doesn't work on internet time, admittedly.

[00:23:39.77] But put it this way, if you don't know who's operating where, particularly when you've got microsats that are so small that you can't necessarily be tracked and monitored, that registry is really, really important. In 2003, Dish was fined $150,000 for failing to move a decommissioned satellite far enough out into a graveyard orbit where it isn't necessarily likely to decay, wobble, and start interfering with the geostationary, geosynchronous orbital slots or become yet another large piece of space debris.

[00:24:26.46] So my view is, I appreciate the notion that particularly internet time is fast. Four years is a long time. Consensus building is tedious and incremental and difficult. But I go back to 2021 when

Messrs. Musk and Bezos were working the refs. They were working the FCC, but working within the rubric of the FCC process, which follows and executes the consensus-- or takes an exception, reservation to the ITU process. They were willing to recognize the legitimacy of the international forum and of the domestic forum.

[00:25:12.85] And it was just a question, narrowly, whether an amendment of your license application shifting your orbital plane usage would put you in the prospect of having to resubmit, or was it just a substantive amendment to your existing application? So in summary, I appreciate that this process is tedious, incremental, slow.

[00:25:38.09] And the treaties don't even recognize commercial actors. They are nonenforceable and have all sorts of flaws. Lastly, in the-- I'll take the license here because we have product placement for Silicon Flatirons. And if this were at the Penn State University, that would be beer, not water. Just saying.

[00:26:01.22] [LAUGHTER]

[00:26:02.62] I want to call your attention to my latest product. It's called "Dangers From Regulatory Vacuums in Outer, Inner, and Near Space." It's in the current edition of the Journal of Air Law and Commerce.

[00:26:14.07] It's tedious. It took a long time. It can take hours to finish. One footnote, but that's my contribution to the literature. As a retiree. Thank you.

[00:26:23.73] DAVID REED: So a question for you then, Rob. You were saying this is a defense for the ITU and the UN. So you're thinking that's reformable, so to speak, for the scalability issues that Gerald is talking about.

[00:26:40.35] ROB FRIEDEN: I don't know if it's reformable. And I know that you've got treaties that were executed in the '60s, and a lot has changed. And they haven't been able to muster the resources to reach consensus, to build trust, to study and find nothing more than recommendations.

[00:27:00.37] So I appreciate that that's a very tall order to reform and move them into internet time. But my concern is consider the alternatives, and the alternatives don't look so swimmingly better in my estimation.

[00:27:17.32] DAVID REED: OK. We'll go, if we can come back on Nate and we'll have Carolyn. Carolyn, are you ready?

[00:27:27.14] CAROLYN KAHN: Sure.

[00:27:28.39] [INAUDIBLE]

[00:27:32.35] Well, it's been great to be at this conference. Thank you. I'm learning a lot, really enjoying the discussion, and really excited that

the students are so involved in asking such great questions. So we're talking about where we're at, how can-- if and how do we apply spectrum management that we use traditionally here on Earth to space, hearing different notions, are there kind of little bandages or tweaks or do we take try to fit a square peg into around hole or vice versa. Or is there something revolutionary versus evolutionary?

[00:28:12.10] So these are important questions. How do we-- with the treaties, how do we evolve that to be more applicable and productive in space? So some unique qualities that makes space different from spectrum management. The huge amount of distance and space, so could make something like the Commons, work there because there's just more area.

[00:28:39.84] But as there's more objects get into space, what will that congestion be? And would that still be viable in those types of situations? Also, that the frequencies that we need to use it, and how do we work within these long distances with attenuation, latency, those delays, the mobile and dynamic environment we talked about with the Leos, the lunar orbits, additional SpaceX launches, and many more expected.

[00:29:16.89] And a big complication is the stakeholders. Just compared to traditional spectrum management, where there are, even on Earth, so many different perspectives and points of views that are important. And then it just extrapolates exponentially when we take it to space.

[00:29:36.03] So how do we work with other countries? What can be agreed on? What rules will be followed? What won't be? What are the consequences or how can they be?

[00:29:46.04] And then the resource scarcity and how economics can help to allocate the scarce resources. Do we make things equitable? Is it first come, first serve? And this is a very competitive environment, where the first-- there is a lot of interest in being the first mover there.

[00:30:07.23] So some highlights with the economics in this space, it is so strategically important. Great power competition, different nations wanting to be that first mover. Although in economics, being a second mover or a close follower has its advantages because you learn from the first mover. The first mover may often invest a lot more money in funding, so more expensive, but makes mistakes, so that second mover can leverage what they've learned from the first mover and sometimes capture more of the market. So there's advantages there.

[00:30:50.20] These are global markets. The international players, the coordination that's required, I mean, no single nation can do it on its own. Because space is everywhere and requires that international coordination.

[00:31:07.33] We talked about throughout the conference externalities and space debris, for instance, and so the unintended consequences and how are those dealt with. We need better ways to deal with those externalities. And whether it's policy and rules or incentives or agreements or how do you take care of the issues after the fact.

[00:31:28.81] And then the collective action that's needed across countries, so that we can have these frameworks. And there's so much common interest. So what do we have in common? And what, as Jennifer Manner pointed out, best practices, what best practices can be established and work toward?

[00:31:48.70] How do we want to deal with equitable access? And these are different policy issues and philosophical goals about what countries will have the rights. Do we want to make it equitable versus the first come, first mover advantage? But first come first mover, those are the ones that often have the resources to provide the funding to use that first.

[00:32:12.94] And then limited flexibility, because these it is such huge distances in space and once decisions are made, and David Goldman talked about it too, with even the regulatory process, but decisions are made early on and a lot of funding and money is invested in it. So then once ready to launch, or even once something is already launched and say, the technology changes or things change, there is limited flexibility to adjust as compared to using spectrum on Earth.

[00:32:43.97] Economic drivers, new business models. Some will be successful, some won't. Learning to see where the funding is and how can we provide the funding, so it's companies but also governments, different countries. So is there a way to work together to pull some of that funding, the knowledge, the innovation to achieve more and better? What incentives are there? What incentives are needed? And just how it can benefit the whole, everybody on Earth, as well as reducing the risks there in space?

[00:33:26.29] So high cost, much more expensive with the big distances. So you do have those significant upfront costs which often take longer to recoup. And then the greater complexities increased risks. So spectrum management on Earth is very challenging. On space, even more so.

[00:33:51.49] DAVID REED: Thanks, Carolyn. And I'm going to jump in from a moderator's prerogative here. The value of this slide that she's put together for you is often, as many of you here know, they are calls for regulation, calls for new laws, calls for calls for new treaties.

[00:34:11.88] But you need to have a justification for those new rules and regulations. And so this provides a nice list of market failures or regulatory failures, one or two things usually is happening there that is causing the problem. And so instead of just a reflexive from a stakeholder perspective saying we need to regulate this, you can get

much more targeted and specific to the exact market failure or regulatory failure that is causing a harm or your problem.

[00:34:50.31] And so this is-- I teach an internet policy class. And when I get a question from the student, why do we regulate? You need to break it down and have a good reason that you're just not reflexively trying to regulate everything. So this is a nice slide that you can take to identify what applies and what doesn't apply.

[00:35:13.49] So I took the questions on your-- do you want to react to that at all or do you-- yeah.

[00:35:20.82] CAROLYN KAHN: Yeah. Thank you I mean this is unknown space. And so I mean, there's legal risks, technology risks. It is truly multidisciplinary. But like, I mean, I do like how you mentioned the regulatory failures versus the business failures. And are there things that can be done incrementally? So it's not so you put it-- you don't want to put all your eggs in one basket, but kind of maybe experiment or try different approaches and see how they work.

[00:35:51.49] DAVID REED: OK. We'll go on now, Scott. If you want give Scott the clicker remote.

[00:35:58.32] SCOTT PALO: Thank you, David. So David said we had five slides. So being a good faculty member, I made 10. And I thought what I really wanted to do was get across a couple of key points here really about aerospace macros, maybe help set the stage.

[00:36:13.10] The assumption is everybody knows what's going on with regards to aerospace and dynamics. Before doing that, I wanted to make an unabashed plug for SpectrumX. So if you're not aware of SpectrumX, you can go to spectrumx.org, but we were founded about four years ago under the National Science Foundation Spectrum Innovation Initiative, and really focused to be the largest academic hub for technology, economics, and policy around spectrum issues.

[00:36:41.49] So I wanted to back up and give a macro view of aerospace to people. Some of you, this may be very familiar, some of this, maybe you haven't seen much of. But if we start from the surface of the Earth at the bottom here and move up in altitude, really about hundred kilometers is where space starts. And you can see there's a plot at the bottom of the blue plot, that's atmospheric density. It falls off exponentially. And we talk about being in the vacuum of space, although you really still have atmospheric drag.

[00:37:14.05] So above 100 kilometers, we transition into space. We talk about the low Earth orbit regime that you've heard a lot about, where a lot of the near Earth objects are flying. There's a really interesting regime below that, let's say from about 200 to 400 called very-- VLEO, Very Low Earth Orbit, where there's a lot of interest there with hypersonic vehicles and ongoing developments.

[00:37:41.93] And we're talking about lunar, so I'm going to keep moving out. But I just wanted to set a point out some interesting things. 400 kilometers, you see there, is roughly where the Space Station and the Space Shuttle fly.

[00:37:54.32] So one of the things that maybe is always assumed, people know something about orbits. So I think the point I like to try to make is you can't just drive around in space like you drive your car. You can't go anywhere you want to. You're really constrained by physics.

[00:38:09.30] And there's a couple of basic concepts here. And the first one here is that your spacecraft typically flies in either an elliptical or circular orbit. So the easiest thing to assume is we're flying in a circle. And that up at the top left there, you can see the plane of the circle is in the equatorial plane. We refer to that as an equatorial orbit.

[00:38:33.96] The middle one is a polar orbit where that plane of the spacecraft is flying over the pole. And then we have a client inclined orbits on the right. And so a lot of the LEO orbits we've been talking about are these circular orbits tend to be inclined or polar orbits.

[00:38:52.55] So you think about there's more popular places you want to be where you're operating in space, there's call it beachfront property as we're going. And down in the lower right over here, you can see on the bottom row, we move from low Earth orbit up in altitude to geostationary orbit. And the key about that is that spacecraft is moving at the same rate as the Earth. So you're saying over the same space and Earth, the same geographic location.

[00:39:19.97] So these LEO spacecraft, they're orbiting the Earth every 90 minutes. They're coming over. They may be overhead for five or eight minutes, and then they're gone. And then the next one comes over. And so this is not to scale, but it sort of gives you an idea of the orbits with the Earth.

[00:39:37.01] The LEO orbits here out to 2,000 kilometers, the geo orbits. You heard a little bit about graveyard orbit. That's how we dispose of things in geo. You move them out to super geo and get them out of the geo orbit because they don't come back and deorbit into the Earth's atmosphere. The things in LEO, we wait for those to come down and ablate and burn up as they come back in the Earth's atmosphere.

[00:40:00.34] I think one of the interesting things to also think about is we don't just fly everywhere in space. We have to think about these other macros. One of the important ones you have to think about is we have radiation belts. We have a natural particle accelerator that makes some of these orbits very challenging to operate in. It causes spacecraft subsets and events. It makes those spacecraft very expensive.

[00:40:22.45] So you typically see we operate in LEO, where we don't have to deal with these things. And then geo is out above the-- luckily, out above the outer belt.

[00:40:34.38] And so this, what I wanted to start thinking about here is looking at where the spacecraft are located and thinking about distance as we're talking about, how does distance impact the ability to operate? And then think about distance in terms of something called space loss. So space loss is the attenuation you have in your signal over distance. And so you can see as we go from LEO out to MEO and GEO, the difference between Leo and is about 1,000 times of attenuation in terms of space loss or 30 dB.

[00:41:13.51] We go out to the lunar environment, that's at 300,000 kilometers. So we have another 20 dB of a factor of hundreds of attenuation. You go out to Mars, depending on where Mars is relative to the Earth, you're somewhere between 50 and 400 million kilometers away.

[00:41:33.41] And I think one of the interesting things from the regulatory standpoint is that the ITU defines deep space as any region of distance. It's 2 millions kilometers or greater from the Earth's surface. So you're thinking about, almost eight times, seven times farther than the Earth-moon distance before you're getting into deep space. So think about from a regulatory standpoint, the lunar environment still in the near-Earth cislunar ecosystem from a regulatory perspective.

[00:42:05.88] There's also things to think about that there are more interesting places to be in space. There are Lagrange points where you want to put your spacecraft in the Earth-moon system or the Earth-sun position, because it doesn't take a lot of propulsion to stay there. So again, thing to point out is as we go from low-earth orbit out to into the Earth-moon, Earth-sun system, there are orbits that are of more interest and are more valuable than others, just something to be taking into account when thinking about where people are going to be operating.

[00:42:37.95] And then I think one of the things we haven't talked about at all, something that I'm super excited about and bullish about, I think optical communications are really the place we should be thinking about heading when we're thinking about operating in cislunar and deep space. There's been a number of great demonstrations.

[00:42:58.27] The LLCD demonstrated 622 megabits per second from the moon to the Earth. Now, granted, that was done on a Lincoln Lab budget using superconducting nanowires on the ground, but it shows you the fundamental capability that you can achieve with optical communications. And you have no atmosphere to deal with. So when you're thinking about, the future, I think we need to be considering optical communications.

[00:43:25.37] And then fundamentally, it is just an eye chart from the Space Development Agency within the DOD. And they're leaning heavily into optical communications for networking of low-Earth orbit satellites. And one of the things I don't think David talked about is that all of the SpaceX, Starlink spacecraft have optical inter-satellite links to connect those spacecraft.

[00:43:48.27] So I want to do just a quick flyby and give some context here and then think about, as we're thinking about the spectrum ecosystem, I think as we think about back here with the distance and the impact that has and how we might think about the neighborhoods as we go and what's happening on the lunar surface versus, let's say, the backhaul links between the Earth and the moon and as we go farther out.

[00:44:15.44] DAVID REED: Panelists, have any comments or reactions?

[00:44:21.05] LYNNA MCGRATH: So I love this slide, and I'll pick on it. One of the things when we start talking about doing lunar and we start talking about doing lunar spectrum management, what's the basis of doing spectrum management? Propagation models. Where's the propagation models for lunar? Actually, that's one of the things being developed right now in the ITU.

[00:44:44.74] GERALD ADAMS: Where?

[00:44:45.40] LYNNA MCGRATH: The ITU.

[00:44:46.18] GERALD ADAMS: Oh, yeah.

[00:44:46.93] LYNNA MCGRATH: The ITU is doing it where-- they're working. And ITS is one of the folks working on developing the p lunar model. And a lot of this is we're missing, in some cases, the fundamental science to do this right. And we're learning as we go. But these are setting up some of those basic things because we think we know how things are going to operate in space from an RF propagation perspective, but we're not totally sure yet.

[00:45:16.22] So we've got a lot of things to learn. And as we go, I think that's going to be having to build into our regulatory models of sometimes we just might not have the right assumptions to start with.

[00:45:28.69] DAVID REED: OK.

[00:45:29.62] GERALD ADAMS: No, I think that's exactly right. And it's vital that we have accurate prediction models, because it gets back to one of my initial points and what was just presented, which is some places on the lunar surface are going to be more congested and more compelling than others. Think South Pole and all of the bases and other payloads that are going to be placed there. Some orbits are going to be much more compelling than others, specifically the Lagrange points that you point out.

[00:45:56.21] And so the impetus behind what I'm trying to stress here is that it's because of that environment and those characteristics that we need some robust management framework that's embedded around clear, understood technical principles, rather than at least what seems to be the cursory point at the moment, which is, OK, well, we'll just go through IT coordination procedures and people will figure it out. I'd like to see something a little more formal and robust than just that reliance.

[00:46:32.45] DAVID REED: So, Scott, can you go to your chart that had the different inclines of the orbits? It's one of the--

[00:46:40.48] SCOTT PALO: I copied it from Britannica.

[00:46:41.78] DAVID REED: Yeah. One of the comments, and I can't remember who it was. I don't know if it was you, Milo, or somebody was talking about, maybe there's room for tightening up what the existing allocations are in terms of the orbit. That it's like 6 to 8 degrees or 2 to 4 degrees. Do you see room in, for at least like the LEOs and GEOs, room for improvement in additional capacity by using newer technology and being able to tighten that up?

[00:47:18.78] SCOTT PALO: I mean, I think when you think about the spectrum management challenge, I know I like the term-- I don't know. Al, you were the one that talked about it or other colleagues, but of electrospace, where it's separating-- you can separate things in frequency, you can separate things in time, you can separate things in code, and you separate things in position,, if you're thinking about how we manage.

[00:47:40.53] And so I guess what you're saying is, can we tighten up the orbital dynamics? I mean, you can fly very precise orbits. I mean, we do that. I'm not sure how much value that brings to addressing the problem, the challenges.

[00:47:59.15] DAVID REED: Well, if the problem is overuse or having too much, if you can get a bit more capacity, more spectrum efficiency, then it's something that's useful.

[00:48:10.89] The other question I had for you, since you're probably tracking it, is how well-- we then had some earlier comments about more and more debris and the different size of the debris, there's a lot more like over millions of really small particles. And is there research going on that is allowing us to track that better? And with AI and to be able to predict that much more? Is that going to be an area of concern for quite a while yet?

[00:48:46.60] SCOTT PALO: I mean, you think about there's the detection. We can use radio radar or optical techniques to detect those things. There's a limit on how far you can go in terms of-- on the radar side, it's just the radar cross section of how much power you're

using. At some point, to get the data into your predictive models, you can only get so far down in size.

[00:49:11.80] Then you have the problem that you have space weather. So I talked about we didn't get into space weather, but that density curve there, it gets really small it has a huge impact. When we have a solar storm, the atmosphere expands a bit. Then the spacecraft aren't where we think they should be based on our basic Keplerian orbital elements.

[00:49:36.69] And now you have to retrack all those things again to find them and get them back into the system. So it's just a fundamental challenge of, A, having the data and then, B, understanding the physics of the atmosphere well enough and understanding how those physics impact the objects s how and where to find them.

[00:49:56.97] DAVID REED: OK. Well, we've got 15 minutes here and I promised that I'd I can go on for a while. And I probably the panelists, we can ask each other questions here. But we start with the WISER rule obviously. And any students that are remaining-- or, Brad, if you see some, I'll let you-- I'd like to--

[00:50:19.11] AUDIENCE: I'll keep an eye out. [INAUDIBLE]. Go ahead.

[00:50:23.63] DAVID REED: OK. There's question.

[00:50:27.35] AUDIENCE: Hello. John [INAUDIBLE]. So, Scott, I want to thank you for hitting on some of the optical stuff that's coming up. But given the fact that the regulations are written very heavily right now in the RF spectrum, but there's not a ton necessarily in the optical realm, where do you see this going as we're about to see a large boom in the optics that are going up into orbit?

[00:50:46.23] SCOTT PALO: Yeah, I mean, I think it's one of the things to think about is, why do we have the regulations in the RF spectrum? And it's to manage interference. It's to manage the users, so that you're not negatively impacting each other.

[00:51:01.99] One of the benefits of optical is just how narrow those beam widths are. And I think at some point, when you get to a sufficient density of optical users, I think it will be something that has to be considered and how we manage that. So I think it is-- in near term, I think, it's less of an issue than it's going to be downstream.

[00:51:25.24] I think there's also a question that I don't know the answer to is when you have tens of thousands of optical transmitters, how does that affect optical astronomy? So there's-- I think some of these things that we're dealing with in the radio spectrum, we can get out in front of them with regards to optical spectrum and how we manage it.

[00:51:51.06] So do I have a crisp answer? I don't. I think we're so early in the stages that some of those things I don't think have really been

coming to the forefront. It's more about, can we actually make things work in space optically?

[00:52:08.70] DAVID REED: And I just would raise with optical that emerging new technology, it's not just space that-- for example, in the broadband deployment area, middle mile is a real problem and particularly getting permits because of various regulations about going over wetlands and the like.

[00:52:30.25] And guess what? With an optical middle mile link, you don't need a permit. You need to maybe perhaps where you're locating the facilities on each end. But it really can speed up your ability to deploy on terrestrially as well. Questions?

[00:53:00.64] AUDIENCE: I'll ask one. My name is Nicole Ela. I just graduated from law school here, and I worked in the aerospace engineer-- in aerospace engineering before law school. I have a question about in thinking about the future of lunar spectrum management, how would you approach the enforcement of any regulations?

[00:53:21.04] With the example of Swarm, I remember when that happened, when I was working, some of my coworkers looked at what they did and thought, wow, that was terrible. And a few people looked at it and thought that was an insane risk, but it paid off in the form of an acquisition. So thinking that there will always be a certain number of people who are willing to disregard the norms of the regulations, what would you propose for the future of lunar management?

[00:53:52.80] ROB FRIEDEN: OK. I'll start. I've thought about that, and I am of two minds. My number one says it's high time that we recognize the stakes of allowing inertia and obsolescence in the space treaties to fester. There are just too many problems.

[00:54:13.12] There are chronic problems, and there are merging problems. So either you're going to get serious or you will get serious because there will be some sort of calamity. And a calamity could be a tragedy of the Commons, the so-called Kessler syndrome, where a very expensive satellite becomes inoperative because it collided with space debris, or ASAT, anti-satellite testing technology, the weaponization of outer space results in a proliferation of space debris.

[00:54:46.57] So one scenario is a clarifying moment, a catastrophe, a calamity forcing the nations of the world to get serious. The alternative is this polycentric necessity is the mother of invention sort of strategy. The problem with that is you get balkanization. You ignore common principles that were consensus driven like the Commons, and you get first-mover advantages.

[00:55:15.99] What you're seeing in manganese nodule prospecting may be a good example of first-mover opportunities-- how much can you extract without establishing property, dominion, and control. So

I'm, as you could see, in favor of the former, but I recognize that they've had 50 years to get serious about it and they haven't so far.

[00:55:44.39] A viewpoint of marketplace sort of driven gold rush, frontier first-mover opportunities sounds very compelling. But then the nations of the world, especially the developing nations of the world, will rally against that.

[00:56:05.72] DAVID REED: All right. Thank you, Nicole. Nicole is actually a graduate of the spectrum management class. We had another question over here. No? No. OK.

[00:56:17.36] CAROLYN KAHN: I would suggest, I think policy research and economic research is needed. With technology, research, and innovation, I mean, policy regulation can innovate Along With the technology. And again, data is helpful. I get-- we need the more science and modeling.

[00:56:39.48] But we can also model economics. We can model policy based on data and assumptions. So working together I think could help develop a solution for that.

[00:56:50.83] LYNNA MCGRATH: And also, I think you asked one of the fundamental questions and one of the things that makes this so difficult. The ITU relies on the sovereignty of each nation to handle that enforcement within their own boundaries. What happens when we don't have that? So I'm the engineer. I will defer to the lawyers to solve that problem.

[00:57:10.51] GERALD ADAMS: Oh, no, I mean, this was in my slides. This is the fundamental problem, I frankly am not sure how to fix it. But yes, the crutch we have always had is sovereignty, because the interference occurs at the receiver. So we enforce it on the ground based on whatever particular nation wants to do to manage co-interference between satellite operators.

[00:57:36.27] We don't have that luxury here. It becomes significantly more difficult to put a robust uniform governance regime in place that everyone respects and wants to abide by. That is really, really hard. And I appreciate what Rob is saying. I lack the same amount of faith that multilateral-- I mean, I might take it further. I don't think multilateralism is going to be the way forward.

[00:58:04.17] I have no faith that it's going to occur, but it becomes concerning because then you're getting into-- you call it polycentrism. I'm going to be even more harsh and say, it's borderline attributed lawmaking. Private entities engaging with their particular governments to create norms that eventually accumulate into custom, I don't know if we have the time to allow that to occur.

[00:58:31.27] ROB FRIEDEN: The flip side is balkanization. I mean, it worked for Yugoslavia. Is it going to work for space policy?

[00:58:37.92] DAVID REED: OK. Another question.

[00:58:40.62] AUDIENCE: Thanks for an interesting panel, David. And just because I can, I'll just tell you that I, too, am a veteran of Dale and Brian Truman's version of the spectrum class, the Maymester.

[00:58:57.96] I want to just, as an engineer, say, there are these things called initial conditions. And terrestrially, I have a lot of knowledge about fixed wireless and terrestrial wireless policy and experience direct experience using it. The thing I also wanted to say about those initial conditions, whether it's terrestrial or orbital, you have a scenario where you're looking at a moving window of spectrum use and policy. And as more use happens, more things occur over time. That was probably one of the most important lessons that the Maymester teaches the students.

[00:59:41.96] My question is, and Carolyn sort of started going down that direction, how does data-driven policy and registration systems accomplish the ability to, in some fashion or form, after the initial conditions are established? Is there a way to track, over time, use of spectrum and be more proactive or ex-ante in your regulation? It's an open question. We don't know what we don't know, but I figure it's a worthwhile discussion.

[01:00:19.22] DAVID REED: Any reactions?

[01:00:19.66] CAROLYN KAHN: Yeah. I mean, I think that would be great to look at the data and so the policy that's in place, what's worked well, what hasn't worked, what are the externalities. And then leveraging what's worked well to tweak and try to make things better over time.

[01:00:39.70] But then that does get into operators that have a lot of sunk costs and investment. And it's not easy to change things up in space, but we can work toward incremental policy improvements with the data-- based on data and using AI machine learning to make it easier.

[01:01:02.25] AUDIENCE: Just one little quick comment.

[01:01:04.29] DAVID REED: Very quick.

[01:01:05.40] AUDIENCE: Ashley mentioned an operational data repository. That's a really great idea. If everybody that's a stakeholder and if you look at it as a multi-stakeholder opportunity, maybe there's a cost to it, maybe there isn't. But everybody benefits. So the incentives might be there.

[01:01:25.80] DAVID REED: OK. Thanks, Dan. Last question.

[01:01:30.92] AUDIENCE: Hello. I'm Jillian Quigley from Wiley. I saw on one of the earlier slides that there were only a few of the satellite bands represented in the list, so I think it said like X, KU, C-band. Are

there certain bands that are better on the moon and the-- which are the ones that we should be using, and which are the ones that we shouldn't be using?

[01:01:55.13] GERALD ADAMS: Great question. I'm not in working party 7B, so I'm kind of pulling second hand what I've been told, someone that is probably can tell you better. My understanding is folks want to economize on the bands they're already using with their payloads. And so C-band is one, X-band, KU.

[01:02:13.99] I think the one that-- correct me, please, the one that seems the most concerning from an outsider's perspective is my understanding is the Chinese have proposed using S-band. And that seems very problematic for the radio astronomy folks on the dark side.

[01:02:29.20] LYNNA MCGRATH: Yes. So it's one of them-- the SFCG does have a lunar frequency plan. So that's out there. And a lot of the-- and that is based on using the existing space research allocations. So it's trying to fit this new paradigm into the existing set of regulations.

[01:02:50.43] That's another topic of conversation of if that's a good idea or not. But given that's the current framework we have, that's what it's built on. So most of the world, as noted through SFCG, has adopted it. China is looking to go in a different direction.

[01:03:06.98] But everyone's got 4.4 rights, and S-band has all sorts of-- anyone who has dealt with S-band understands all the issues that come with S-band. And I will not spend how much time-- talking about how much time we spend doing S-band coordination. But it's one of them of I think everyone's trying to figure out how do we do this. And it's the last frontier brave new world.

[01:03:33.12] Pick whatever favorite sci-fi phrase you want to use to describe this. We're all trying to figure it out, and we're using the frameworks and tools we currently have. And I think the very accurate question is, does that make sense for where we're going in the future?

[01:03:49.37] DAVID REED: Anybody else? Well, we are just right on time. And I want to make sure you get to lunch here or the other session. So please join me in thanking the panel here for some excellent comments.