

Center for Strategic and International Studies

TRANSCRIPT
ONLINE EVENT

**Dancing Lights in Space: How to Manage The Risks of Satellite
Close Approaches in Geostationary Orbit**

DATE/TIME
Saturday, January 26, 2022, at 10:00 a.m. ET

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Transcript by Zoom and CSIS

Todd Harrison: Okay, good morning everyone. Why don't we go ahead and get started. My name is Todd Mr. Harrison, I am a senior fellow and director of the Aerospace Security Project here at CSIS, and it's my pleasure to welcome you all to this exciting webinar that we have today with a really great lineup of speakers.

I'm going to go through the format for the event really quickly.

And the first thing I want to bring to everyone's attention is that we will be taking questions from the audience and the way you can ask your question is in your zoom window at the bottom, you should see a button that says Q and A.

If you click on that button, you can see questions that other people have asked you can upvote them if you see a question you want to make sure it is brought to our attention. As they get upvoted they're going to rise up to the top of the list that we will be looking at. If you don't see your question already in there you can type it in and submit that for us. We'll try to get to as many of the questions as we can throughout the event for all the different speakers that are coming up.

And in terms of the agenda for the event, we're going to start off with a keynote address by Audrey Ms. Schaffer. She's the director of space policy on the National Security Council. So we're really glad to have her.

Then we're going to go into the first panel discussion of the day. That will be moderated by Makena Ms. Young from CSIS and the topic there is how well can we monitor and characterize close approaches in GEO.

After that panel discussion concludes we're going to give a brief demo of the new tool that we're rolling out today that's been a joint effort among CSIS and Secure World Foundation and the University of Texas at Austin.

That is our satellite dashboard, Kaitlyn Ms. Johnson's going to do a short demo of that. Then we'll roll into our second panel discussion of the day, policy and norms, to manage close approaches. The moderator for that is going to be Brian Dr. Weeden from the Secure World Foundation.

Without further ado, let's jump right into it. I want to introduce our keynote speaker for today: Ms. Audrey Shaffer. As I mentioned before she's director of Space Policy at the National Security Council. She was previously Acting Deputy Assistant Secretary of Defense for Space Policy and she worked in various positions in that office for several years. And before that she was at the State Department and the Bureau of Arms Control, Verification, and Compliance.

She's had a great career in space policy and it has been to CSIS before spoken at events before and we're glad to have you back Audrey. So, want to turn it over to you to make some opening remarks.

Audrey Schafer: Alright thanks Todd for the introduction. Thank you, Brian, for inviting me and thanks to the entire Secure World and CSIS team for hosting what I think is going to be a really fascinating event. I am honored to be here with you today—I think I see on the screen over almost 300 participants, which is fantastic. There's so much interest in this issue and I'm also pleased, of course, to see so many friendly faces in that list of folks.

So before I go into specifically talking about sort of the key issues for today space norms and interactions between satellites in GEO, I did want to spend a few minutes just sort of setting the stage, broadly speaking, and talking about this administration's space policy and space priority. Hopefully you all saw that on December 1st of last year, the administration released a document we're calling the United States Space Priorities Framework. It was released at the inaugural National Space Council meeting, chaired by the Vice President, which had participation from across the National Space Council departments and agencies. At that meeting of Vice President Harris and all the Council members highlighted really three areas where this administration intends to focus on its initial space policy efforts. One: developing norms of behavior for space activities. Two: using data collected from space to help address the climate change, excuse me the climate crisis. And three: using space missions and achievements to inspire the next generation to pursue education and careers in science, technology, engineering, and math.

And for those of you who haven't watched the video from the meeting I'd really recommend it to you. It was for me it was just incredible to see such a diverse set of cabinet secretaries and other senior officials from the U.S. government describe the many ways that our nation leverages space for the benefit of the American people and frankly for people around the world, and what our government is doing to safeguard those benefits for current and future generations. I personally learned a lot and I've been a space professional for my whole career so I really would recommend it.

And so I'm going to focus on one of those three priorities that they highlighted: the norms piece, but I think if you were to think that sort of those three areas where the only areas that this administration was going to prioritize from a space perspective, you'd really be missing the broader set of themes and focus areas that are described in that space priorities framework document.

So I wanted to spend just a few minutes really unpacking that and laying out comprehensively what this administration cares about with regard to space.

The framework itself and by that I really mean the document and I forgot to bring my pocket copy so I don't have, a thing to hold up for you but it's blue, it's got stars on the front so it's really nice looking publication. The document really has two sections in it. The first is U.S. benefits from space activities. In other words, how does our nation and really all nations and people around the world benefit from space programs and missions.

The second is U.S. space policy priorities or in other words, what are our nation's priorities for space policy regulation, programs, investments, etc.

And when we look at that first section of how the United States benefits from space activities, the framework breaks that down even further into two categories, one which is more domestic looking at how space is a source of innovation and opportunity for Americans. And the second which is more international looking at how space is a source of American leadership and strength around the world.

Some examples of those domestic and international benefits which I'm sure this audience is quite familiar with are all the ways in which space enables both the U.S. and the global economy, PNT of course being the best example. And also all the ways in which space enables us to do weather prediction and preparedness and response to natural disasters, all the various international partnerships that we use space to advance whether that's the International Space Station, the Artemis program, or some of our military to military cooperation. And finally, how space is truly an enabler for us power projection around the world, whether that's to respond to humanitarian crises or tensions between nations.

The other half of the document which is the Space Policy Priorities is again broken down into two sections. One, which is more domestic looking, at how we maintain a robust us space sector. And the other again which is more international looking at how the United States will lead the global community and preserving the use of space for current and future generations. The items you see in the U.S. space sector priorities really shouldn't come as a surprise to anyone—they're truly long-standing space policy priorities that typically endure across administration's. They have bipartisan support, things like maintaining U.S. leadership in space exploration, enabling a commercial competitive U.S. commercial space sector, protecting and defending U.S. interest—both those on the ground and those in space from natural and man-made threats.

And then we when we look at the very last section on preserving the use of space we see the emphasis on the global issues that we're here to talk about today: strengthening governance of space activities, bolstering SSA sharing, and space traffic coordination.

So, digging down into that area, the underlying principles I would say motivating this administration's approach to global space governance are really the same principles that underlie its approach to other global security challenges. These principles are articulated in the interim national security strategic guidance, which was published last March again another document I'd recommend to you if you haven't read it. Just to highlight three of those principles. First, it's a recognition that the alliances, institutions, agreements, and norms underwriting the post-World War Two international order that the United States really helped to establish are now being tested, and the U.S. has an opportunity to adapt and reform those structures, along with our alliances and partnerships to address the challenges of this century, and to sustain an open and stable international system.

The second principle is elevating diplomacy, as the leading instrument of American foreign policy, whether that's working with like-minded allies to figure out what those institutions and norms ought to be or having frank conversations with China and Russia about their destabilizing and assertive behavior.

And finally, a core principle is building and leveraging our strength at home to bolster our ability to lead internationally.

And so when you look at those three principles and you really reflect them back into the space arena and you look at our space priorities framework, you see that, sort of translated into a space context. At home, we need to maintain a robust and competitive domestic U.S. space sector, that really continues to innovate and push the bounds and having that strength at home, enables us to lead internationally in the implementation of both existing norms and guidelines for space activities as well as in the development of new measures to really strengthen that rules-based international order for space.

So digging into space norms now. When I look across both existing and emerging space activities, I see three categories of norms. The first is what I'm calling like basic spaceflight safety norms those norms that everyone should follow regardless of whether you're a commercial operator, a civil operator, military operator, an academic operator—my kids third grade class launching a satellite in space, whatever.

Everyone should follow the same spaceflight safety rules in order to enhance safety and predictability in the domain, just like we all follow the same traffic rules, more or less, on the road. And that's really to protect sort of everyone's safety as well as the sustainability of the environment itself.

The second bucket of norms are really those norms for how we operate on the frontier, if you will, in pushing the bounds of space exploration. Whether that's how we cooperate in developing cislunar space, exploring the lunar surface, how we responsibly utilize space-based resources, how we share information with one another in our scientific endeavors, and how we protect those humans who in increasing numbers are going to space.

And the third category of norms is norms specifically for military activities, norms that reduce the risk of miscalculation and threats to international peace and security.

Now if you look across those three areas in some I think our focus really should be on the implementation of existing measures. In the space flight safety and sustainability category, the United States is one of the world's leaders in implementing the various UN guidelines that we have, whether that's the Debris Mitigation Guidelines from 2007 or the 2019 Guidelines on the Long Term Sustainability of Outer Space, and within the United Nations Committee on the Peaceful Uses of Outer Space, the U.S. like routinely delivers technical presentations and other statements showing how we translate those international guidelines into domestic law regulation and policy here at home.

And while I don't want to suggest that there isn't more work to be done in this area, particularly for new space services and applications that don't like neatly fit into existing categories, or frankly for just a growing number of satellites that we're seeing on orbit. We have to all start both domestically and internationally from that common baseline of implementing the guidelines that we have in place today.

If I turned to the second category the norm for the frontier category. Our focus in the U.S. is on the Artemis Accords which were first announced in 2020. And those Accords are really for governing and civil space exploration activities are focuses on both expanding the nations who are committed to the Artemis Accords and committed to the principles and norms there and also really putting those into practice as we advance our space exploration activities through the gateway, the Artemis missions, really, to ensure that we're sort of operating consistent with the norms and the roles that we've laid out in our ability to put those forms into practice and kind of solidify them is to some extent dependent on our

ability to lead by example, which is why having a robust space exploration program really does enable our global leadership our galactic leadership, if you will. Because that enables us to demonstrate what that responsible behavior looks like.

And then the last category is military norms I think we're very much still in the realm of developing new concepts and measures, although we are starting to see some progress in that area, driven largely by the 2020 UN General Assembly Resolution 7536, which solicited states views on threats to space systems and ideas for norms rules and principles responsible behavior.

The U.S. submitted an input to the UN Secretary General in response to that resolution, and last summer Secretary of Defense Austin also issued a memo outlining the tenants of responsible behavior for DOD space activities and I think both of those documents will serve as important foundations for future U.S. work in this area.

And in that regard on December 1st at that Space Council meeting which I described earlier, Vice President Harris asked my boss, the National Security Advisor, to bring together DOD, State, and others to develop concepts and proposals for national security space norms and she also asked the Space Council staff to develop an overarching plan for how we bring together, and advance norms across the board as well.

And so I'm not able to preview the results of any of those efforts for you today I can assure you that the interagency is hard at work, looking at concepts for norms that support international peace and security, and are in the interest of the United States and its allies and partners. One final area just as a quick—not really footnote but just a quick area, I'd like to flag from the space priorities framework is really both domestic and international in nature is leading the development of space traffic coordination and by that we mean the system of standards, practices, policies that enable space operators to coordinate with one another as well as with providers of space situational awareness and spaceflight safety information in order to avoid collisions and other mishaps in space.

I think this is an area that's really ripe for cooperation between the public and the private sectors between the United States and other nations and between civil and national security actors. And really it's something we can't do without cooperation. We're all sharing the same orbit, the same operating environment or literally no national borders of space, so we have to find a global solution. I know my colleagues in the Space Council are really hard at work on this issue because it cuts across literally every

aspect of US and international space activities and requires that integration across all the U.S. space sectors.

And so before I wrap up and I know I'm running short on time, I did want to talk just briefly about operations in GEO since obviously that's why we're here today. The U.S. and many nations—really all nations— depend tremendously on a safe and secure GEO belt, because of the critical missions that are supported by satellites in GEO right. I talked about in the beginning of my remarks. The benefits we accrue from space activities data to help us understand climate change, global satellite communications that enable commerce right, all of those benefits and more, really to depend on our access to and use of GEO.

And with the advent of space-based surveillance, satellite servicing, satellite inspection, we're going to see more cooperative and potentially uncooperative close approaches between space objects.

And the very same behavior—inspecting a satellite for example— could be perceived very differently depending upon who's doing the inspecting, what they are inspecting, and how they're conducting the inspection, and how that behavior is perceived both by the other actor as well as by the community at large, could literally make the difference between what's a non-event and an incident of serious national concern, as we've seen with some of the on-orbit weapons testing that's happened over the past couple of years.

So it's really critically important that we develop basic norms for satellite to satellite interaction to avoid the risk of miscalculation and misperception. And I don't claim to have all the answers here—that's why I'm really glad that an event like this is happening today because we need to have more dialogue on this issue.

But I do think we need to really start from first principles, basic concepts like transparency. What information do we share with whom coordination, how do we communicate with one another and coordinate our activities? Safe separation distances, especially in instances where you don't have transparency or means to coordinate.

Those sort of three concepts which are easy for me to say but I think be challenging to define and practice. I think often form at least part of the foundation for developing those norms for responsible interactions between satellites in the GEO belt.

Mr. Harrison: Looks like we lost a video there for Audrey I want to give it a second to see if she's able to reconnect. One moment. Oh, there you are.

Ms. Schaffer: So sorry, I don't know why my government issued laptop decided to shut down right in the middle of my remarks, but I can assure you that I was actually just about to say thank you for the opportunity to speak and turn it back to you, Todd.

Mr. Harrison: Well I guess if it had to happen, it was a good moment. Thank you, those are great remarks to set the stage for this discussion today. I did want to go through, I have a few questions for you.

My first question is if you could just talk a little bit about your initial reactions to the Russian ASAT test back in November. I actually asked the same question to General Raymond when we had him at an event last week, but I just want to get your perspective as someone who's worked in space policy in government for many years. What were your reactions when you first learned about the Russian ASAT test? What do you think that means in terms of affecting the way forward on reaching some sort of consensus about norms of behavior in space?

Ms. Schaffer: Yeah, thanks Todd for the question and can I just confirm you can hear me okay? Because I'm on my phone now.

Mr. Harrison: Yeah, I can hear you just fine.

Ms. Schaffer: Okay, so I'll be honest with you: I was actually surprised that they did that they did such a irresponsible and reckless act. The Russians are very capable space operators, they have some of the best astrodynamacists in the world. They presumably knew the kind of debris implications of what they did and how it would affect not just the International Space Station and then distribute abstract way but literally the lives of their own cosmonauts who are on board. So I was actually surprised, and maybe I shouldn't be given sort of current events in Europe right now but I was actually surprised at how brazen the Russians were with that act.

And I think we have seen—to your question about whether that will sort of galvanized public opinion— I do think we've seen a real sort of sea change in attitudes over the past, since the test really promoting the idea of stronger norms against regenerating anti-satellite testing you saw at the Space Council meeting on December 1st Defense Secretary Hicks, say something along those lines, I don't want to quote her because I don't have her words in front of me, but it was a pretty forward leaning statement from a U.S. government official. And so I've started to see that reflected in the media and in think tanks or op-eds written by some of the, like co-panelists today. And so I'm actually quite hopeful that we'll see some progress in that area over the next couple of months.

Mr. Harrison: Next question I want to dig in a little deeper, what you talked about in your remarks about reaching some sort of a consensus on norms of behavior in space and you divided it into three categories and maybe your answer is going to be different by category but question is, what do you think is the most likely most fruitful path forward at this point. Is it through the United Nations? Is it something outside the UN and who are the key players that we really need to be coordinating with to make progress?

Ms. Schaffer: Yeah, thanks for the question Todd I mean I think it depends somewhat on which of those buckets you're talking about, for example, if you're talking specifically about the risks of miscalculation and misperception between nations you really need to make sure you're actually capturing those nations who are likely to come into, to have those risks present between them so for example if the United States like went off in his corner with all his friends and came out with something not sure that would necessarily be as effective as say working something directly with Russia or China or some combination thereof.

But I think kind of regardless of where you start and how you sort of forced formulate the kind of the words on the paper the agreement, it's actually quite important to bring those norms and guidelines to the United Nations to get that sort of broad international support, consensus, and buy-in because it's obviously an important starting point for kind of a group of most effected nations to agree this is the way forward. But really the global normative effect of bringing something to the UN is something I think is quite powerful.

Mr. Harrison: So the next question, one from the audience, from our colleague of the Secure World Foundation, Victoria Samson, is do you think there would be U.S. interest potentially in signing developing some sort of incidents in space agreement that would provide more guidance for military activities and space?

Ms. Schaffer: Yeah, thanks for the question, Victoria. I'm personally somewhat agnostic in terms of the form of such norms, whether that's an agreement that looks like the incidents at sea, right, incidents at space, or whether that's say like a code of conduct like the Europeans promoted almost 10 years ago now, or whether that's a set of guidelines that are at the UN, I actually personally think that's the most important thing we need to focus on is what is the substance: what are those rules or standards or guidelines or whatever that we're all going to agree to follow to avoid those misperceptions?

And then we can figure out what sort of the heading of the document is and how it's negotiated and all that. But this is the area where I think we

have a lot of intellectual work to do, especially on the national security side. I mean that's really where I've been focusing a lot of my time lately.

Mr. Harrison: Alright I know you've got a busy job. I want to ask one final question before we let you go, question here from Mark Meyer in the audience about building a legal framework for debris, clean up and recycling and I would note that related to some of your remarks, there can be ambiguity on that right because that could be if you have a company out there or a nation state that's going to do a close approach to grab some debris, who does that debris belong to? What kind of legal rights do they have over that debris? How do you get consent for cleaning things up? So I wanted to get your thoughts on how do we build some sort of a legal framework and structure for doing debris clean up and hopefully one day recycling that material to use it in space.

Ms. Schaffer: Yeah, thanks for the question I mean we have an international legal framework that does provide kind of the parameters ownership, for example, of space activities. And I think that legal framework does allow for cooperation and, frankly, agreements to be signed between nations to enable the kinds of debris clean up that you're talking about.

You know yes, the debris sort of is the government exercises jurisdiction control, supervises that debris sort of indefinitely. That doesn't preclude that government from having an agreement with another government to address things like liability for example for how that operation ought to be conducted who's liable in the case of harm or how the liability is split, for example. So I mean I actually think we have the legal framework we need, we just haven't really put it into practice in terms of creating the agreements between the actual actors who be doing the operations in order to sort of test it, if you will. And I think until we do that it'll be hard to say, where there are legal gaps, because we haven't tried yet.

Mr. Harrison: Yeah. Now, the great thoughts there and Audrey, I want to thank you so much for joining us today. This is a great way to kick off the event, and hope to have you back in the near future.

So with that I want to turn to our next scheduled part of the event here today.

It's the first panel discussion of the day so hopefully you can see the introduction slide here, and Makena Ms. Young want to bring her up she is going to be the moderator for this panel discussion so Makena over to you.

Makena Young: Hey, thanks so much Todd and thanks again to Audrey for those wonderful remarks. I'm very excited to keep the conversation going as we

focus on our panel on how well we can monitor and characterize these close approaches in GEO.

This is being the U.S. international actors and the commercial market as well. I'd like to thank our three panelists for taking the time out of their busy schedules to join us today. For some housekeeping, I'll just take a minute to give some brief introductions of each of our panelists, then turn it over to them for some opening remarks before we go into an open discussion with questions from myself and from the audience. So as questions arise, please feel free to type them in the Q and A box. You can ask questions as our panelists are giving their opening remarks, and I'm really excited to get into this.

So first I'm pleased to welcome Dan Mr. Oltrogge. He's the Director of the Center for Space Standards and Innovation, Director of Integrated Operations and space policy expert at the Commercial Space Operations Center at COMSPOC Corporation, also program manager of the Space Data Center, founder and administrator of the Space Safety Coalition, U.S. Head of Delegation to ISO TC20/SC14, and the author of numerous technical papers international space standards and industry best practices.

Also with us is Mark Mr. Becker. He's a Policy Officer and the Department of Space Situational Awareness at the German Space Agency within the German aerospace center or DLR. He currently serves as co-chair of the European Space surveillance and Tracking or EUSST program. He also chairs their Internal Security Committee since 2019 dealing in particular with security and policy requirements for the handling and sharing of SST data. Prior to this, he worked with the German Ministry of Defense's Director General for security and defense policy as a desk officer for security policy

And Dr. Brian Mr. Flewelling is the Innovation Boffin, ExoAnalytic Solutions. In this role Dr. Mr. Flewelling works closely with engineers and scientists to establish develop, communicate, and deliver technical solutions that apply to ExoAnalytic's core technical capabilities and the physical and digital engineering domains in the physical and digital engineering domains. Dr Flewelling is an aerospace professional with government, academia, and industry experience that has been recognized in each of those sectors as a thought leader.

So thank you all so much for joining us, I'd love to kick this off by asking Dan to tell us a bit about U.S. capabilities and how close approach monitoring characteristics have developed at COMSPOC. So thank you all again for being with us.

Dan Oltrogge: Thanks, Makena. Can you see my screen? Just verify.

Ms. Young: Coming up here. Yes.

Mr. Oltrogge: Okay. I just got a message that zoom quit unexpectedly but I'm still here. So, I'll participate, continue.

Thanks very much to Brian for inviting us to participate in this. This is indeed very interesting and important topic in my opinion that hasn't gotten enough attention. We've really been focused on LEO cut large constellations and new space. But meanwhile GEO commercial spacecraft tend to be bigger, more expensive, and more likely to hit other at (*zoom disconnects*). Even their conjunction geometries are fundamentally different. I'm showing in this no debris flies past the active satellites in green, from a north (*zoom disconnects*)

Want to verify I'm still on zoom just did something strange again.

Ms. Young: You're on you've been breaking up a bit your screen sharing stopped though.

Mr. Oltrogge: Okay, let me start that again. Apologies.

See, I think it's this one.

Mr. Oltrogge: Are you seeing my animation video again?

Ms. Young: Yeah, we're at back at your, your first slide.

Mr. Oltrogge: Okay, so I want to touch on three basic topics today. First I want to talk about kind of the history of the SSA capabilities, especially in the U.S. that we have. And I'll discuss some of the challenges of GEO SSA, in particular, and follow that by the emergence of commercial SSA, I'm sure Brian Mr. Flewelling will also be a talking to that and how we can help spacecraft operators.

So first let's talk about the SSA history and the legacy of capabilities. We have many of these algorithms and tools that are operational today we're actually developed and implemented in the 1970's and 80's, back when space truly was a sanctuary. We had spacecraft that were purpose built, and many of the algorithms and con-ops used for SSA were designed and developed for kind of a benign space environment which we've enjoyed for decades. The required accuracy of SSA actually in the early days was just that we'd be able to point sensors to reacquire objects. And it wasn't really intended for the environment where spacecraft continuously monitor a maneuver, and even conduct for proximity operations and

rendezvous on-orbit servicing low thrust maneuvers, and probability-based collision avoidance. So things have fundamentally changed now.

But we now recognize it today's as to say services are insufficient for our current environment, and the way that SSA data is being used by the operators. Not only are the high availability and resiliency and scalability critical, but we also need an SSA product that is able to generate a quality decision...decision-quality SSA information, meaning that it is sufficiently accurate and comprehensive and timely and transparent so decision makers can use it for their operations.

So now what are our opportunities to address these challenges? Well first we can start to construct and operate data lake flight safety systems, such as a space data association.

I'll talk about that in a moment. And also the concept of the space satellite database.org website that you'll be hearing about later today, I think that's great.

Secondly, we can work on leveraging commercially available, modern software architectures tools and algorithms to get a better, more decision quality product.

Now first I'd like to kind of talk about the risk of collision in GEO. It's really actually a difficult question to answer because assessment techniques you might use and LEO to assess this often don't work well in GEO— it's a special environment.

This graph with longitude on the x axis over here, and conjunction or collision rates on the y axis, is summarizing 15 methods we employed in our 2017 paper to look at GEO risk, and the red and orange lines, respectively, show the risk of colliding against one centimeter and 20 centimeter debris, whereas the green line shows the risk of colliding against currently tracked objects.

You may wonder why these two peaks exist. That's because that's where gravity wells exist and debris tends to oscillate around those areas.

This chart, just summarizes kind of where the risk comes from and GEO for so if you have an active GEO satellite, what is the secondary guy that you might collide with? And actually more than half of that is with active satellites is shown in the blue and the red pies down here, whereas in debris, it's debris that tends to be in the 10 to 30 degree inclination orbits that pose a threat.

Speaking to one of the questions in the chat from earlier, this is an animation showing where debris can go if we do have a collision in GEO.

And the interesting thing to me is just how quickly that debris spreads around the whole GEO belt. So if you think you're at one longitude and a collision and another longitude won't affect you, think again.

This graph shows as a function of time from orbit determination errors so this is how far you predict your positional information in the future. What the accuracy of various solutions are. This was something that came out of our space traffic coordination and management demonstration of data fusion we did in 2020. We worked with commercial SSA service providers, the Space Data Association, U.S. Space Command, Department of Commerce, and five different spacecraft operators operating at all orbit regime.

This part here is unique to geosynchronous orbit. And it just shows a relative comparison, and the emphasis of this is to focus on how well how much better we can do if we fuse data in a collaborative community-based way, we can get a between 10 and 30 times improvement by, by doing that fusion.

In terms of the company I work for, COMPSOC, we provide a bunch of comprehensive flight safety and space domain awareness services over on the left here, we have commercial products for flight safety and services. And then we also run the Center for Space Standards and Innovation. I was glad to hear, Audrey mentioning the importance of space standards that's one of the ways that we contribute to that.

Taking it one step further, we need to at least be aware of the Space Data Association, they're in their 12th year of providing full operations, there are some 32 operators that participate. And this is flight safety ongoing high availability and high quality and accuracy. The STC that we operate for them, it has been a pioneer of lot of flight safety services aspects that today people just assume as, well, logically you do need that capability and instead of those attributes.

You know twelve years ago, we really hadn't established what attributes were required and I think this Space Data Association is has led the development of that.

And these are the various satellites that are involved in the STC, it's an ever-increasing collection of operators and satellites, with over half of them in LEO but in GEO representing over 50% of the active GEO satellites. So I'll leave it there. I look forward to questions and my colleagues, talking points. Thank you very much.

Ms. Young:

Thank you so much, Dan, and so I'm going to turn it over now to Mark. If you can tell us a bit about the European operation, and the European

Space surveillance tracking program, kind of how your operations are run and your capabilities GEO and your services to spacecraft operators.

Marc Becker:

Thanks, Makena. Good morning and good afternoon, everyone, and thanks to CSIS and Secure World Foundation for organizing this event and for giving me the opportunity to present European space events and tracking EUSST

And what I'd like to do is to give a brief overview on EUSST, including our capabilities and services covering the GEO region, then discuss different kinds of close approaches that we see, and end with a note on some of the challenges that we are dealing with which we can explore further in the in the Q and A.

So we started with SST on a European level six years ago. And to date EUSST is a fully fledged space program of the European Union.

We are currently seven year member states that joined forces and network their SSA capabilities to provide space safety and space traffic coordination and management services to satellite owners and operators, but also to the EU itself Member States, public institutions, silver Protection Agency's and so forth. So in that, that sense we are we're also contributing to the implementation of some of the norms and guidelines that were mentioned by Audrey Shaffer, such as the LTS guidelines. And soon we will be 15 member states and a new extended SST partnership that we're currently forming. And this means that we continue to add additional resources and grow our capabilities.

Apart from improving our sensor capabilities, this new partnership will also include the development of new services to support space debris mitigation and remediation activities.

Today EUSST is fully operational 24/7. So we operate a sensor network of some 40 radars, telescopes, and lasers and chair 400,000 measurements of space objects from all orbit regimes.

Every day we joined database, which we use together with data from external sources to generate services that protect today 250 European satellites from the risk of collision.

So further improving that European capability is a strategic objective for us. And today we only have a limited degree of autonomy in many cases we rely on data that we received from the U.S.

But we invest a large share of our budget in research and development activities and improving our system also together with European industry and startups.

Now regarding our coverage of the GEO region. We currently operate 28 telescopes, 18, mostly for surveillance, and 10 mostly for tracking purposes. And most of these are located in mainland Europe. We also have a few sensors overseas. But that means we still have some, some gaps in certain areas such as over the Pacific. And that means it's just more difficult for us to monitor certain parts of the GEO belt while we have a very good visibility of other parts.

However, by 2023 and we expect to upgrade and grow to almost 40 telescopes and our architecture studies that we conduct regularly indicate that this will help us to achieve a high level of autonomy and observation objects in GEO, and we expect indeed that all objects and GEO above 3035 centimeters will be catalog then.

Today we have 118 spacecraft from 16 organizations in the GEO region that receive our collision avoidance service. This includes satellites from mutual start, FES, Astro, just to name a few examples. And also number of governmental or military communication satellites of our Member States

Coming to my second point in terms of terminology and I think Audrey also touched upon this a little bit. I think it's analytically useful to distinguish between approaches that do not constitute the safety risk per say and close encounters that may trigger collision warnings or amount to a close proximity operation, whether that is coordinated or not.

And for example in the satellite dashboard that you're going to present today, I think it shows many cases where the approaching object is still 10, 30, or even 50 or more kilometers away from another satellite. And while, such cases maybe a disturbing or understood in different ways and so this unfriendly behavior from national security perspective, they do not necessarily affect the normal operations of the approach spacecraft. At least, there is no immediate risk of collision and at those distances. And usually this, this would not require any collision warning by EUSST for instance. Of course as the operator of an approach satellites, you may want to stop certain or take other measures if you assume someone is trying to type in your communications for instance, but these are things that are being handled by our military partners, for instance.

And then uncoordinated maneuvers in close proximity of another satellite GEO say in a instance of less than 10, or five kilometers. Those are different story, because then you operate with limited data probably limited information on intent. And then we run the risk of miscalculations misunderstandings and probably amounting to real threat that can also be termed and national security terms.

And of course at a certain point, and then for tracking it can get quite tricky to reliably track and distinguish two objects, if the distance is below several hundred meters for example.

So, so our business in the EUSST it's not on those security aspects specifically even if some of our products may be useful in such cases as well and we have military users as well and militaries, and your contribute to us as to as well. But our primary focuses on the safety aspects and on providing data and services to handle collision risks and server predicted conjunction crosses certain threshold in terms of probability of collision on this distance.

And those are agreed individually with each, each of our users. We provide the users with different kinds of products such as wanting notifications, or alerts. And then we can also support a maneuver planning later on if required.

So, luckily, it is still quite rare that our users in GEO have to dodge space debris, or about a collision with another active satellite, compared to LEO traffic, GEO is still relatively calm you have lower speeds, many of the objects are well tracked and you don't have as many disturbances in tracking objects normally. But nonetheless, the situation is far from perfect, and this is my last point, operations in GEO are based on incomplete information as mentioned by Dan. And for instance in the EUSST, we receive the owner operator ephemeris from our users, but not necessarily those of the other GEO objects from GEO operators.

And if you do not factor in certain tent maneuvers, for example, you tend to end up with a significant number of false alarms. And if you picture satellites in GEO belt as pearls on a string, each in their respective assigned slot or boxes, but each also drifting a little bit so every other week they need to conduct a small station keeping maneuver. And then when one object already performed the smaller just adjustments and the neighboring satellites haven't done so yet, it might appear that those objects are drifting towards each other and that may generate a collision warning, which may only be theoretical in reality because if you had all the information on planned maneuvers, you could see that coming that's actually not a real risk there.

And that's just one of the challenges we are we're dealing with in GEO and where we're working on better solutions providing better solutions. But I'll stop here for now and perhaps we can again delving deeper someone to this aspect from the Q and A. Thanks.

Ms. Young:

Thank you so much, Mark. And we have some good questions pouring into the Q and A so I'm excited to get to that as well.

And now that we've heard from two of the most prominent government actors in that domain in GEO, I'd like to turn it over to our resident commercial expert on the panel.

There's been a real explosion of commercial success in SSA in the last decade or so. So, Brien, I'd love to hear more about your work at ExoAnalytic and how you monitor and characterize close approaches and

Brien Flewelling: Thanks Makena and to CSIS and Secure World for this event, we're really excited to talk with you today about that. Let me make sure I share my screen here. Please let me know in the slides are coming through.

And thanks to Audrey Shaffer and to the other panelists for your remarks thus far, I think it sets the stage the really well.

So you seeing my charts?

Ms. Young: Yeah, pretty good to go.

Mr. Flewelling: Awesome. So, I want to give you a perspective that we have in the commercial sector, particularly here at ExoAnalytics. We built a network of more than 350 telescopes that we consider a human computer interaction system with an integrated and deployed AI, ML solution that's been trained by the largest and most painstakingly curated SSA database in the world.

You get to do that by bringing in more than a million measurements a day that we've really tuned it, designed it to be able to address today's problems that have been described already by the other panelists. Taking a persistent approach and doing this globally, our users can perform command and control so they can pass our telescopes they can they can support their operations in concert with what we can observe.

We provide automated learning for maneuvers post changes and deployments in real time. This comes down to a solar exclusion. That's something like four and a half hours. This is achieved by the global proliferation of our sites and the performance that we can achieve with our sensors. And as we estimate, our positioning on objects that we observe we can get our orbits down to, as good as 30 meters. So that's 10 to 30 times improvement that Dan was describing I think it's realizable and when we can speak to that from some experience.

In terms of closely spaced objects. I will show you a few examples where we've demonstrated tracking down to within a kilometer separation. And

we do need to distinguish between different types of events that can occur in GEO. So certainly, fly by events between debris, as it poses a hazard or a risk to operational systems, as well as just systems that are having a bad day and perhaps have had an event on board that has led to the generation of debris and there's been a few those in the news in the last few years. Importantly debris that has been shed from some of these objects has at least an angle space been perceptually proximal to neighboring spacecraft and it's something that needs to be monitored and be a continuous concern.

So as we achieve our overall sensitivities of approaching 21st magnitude, think about being able to see a baseball at GEO, these detection ranges or something what we're also pushing far beyond GEO as we consider these operations and extended regimes like cislunar space. So, the first example, I'm showing you our tool Exomaps, and this is describing a close approach that occurred between a piece of debris and Inmarsat 4-F2.

And you can see in the lower right where this piece of debris is coming in and getting close to the spot sites there, and as we in retrospect have fit the orbits and done a deep analysis of this we believe that this passed within 1.5 kilometers and you can see the precision of fit here, it's a plus or minus 33 meters. So, in the case of this spacecraft, our recommendation was not actually to do any sort of evasive maneuvering

This is because of the confidence we had in our fits of both objects. So being able to have persistent and high quality data allows us to support these operations in a different way, basic services might lead to a larger uncertainty and therefore lead to a conjunction data message that could lead to an expenditure of fuel as a resource to avoid the situation. But with higher precision, more frequently updated information, this helps us support GEO, in an improved way.

Further, if we were to distinguish from flybys between debris or an inactive object and an active object to intentional close approaches at GEO, we might talk about the recent unbelievable successes of MEV one and two. In this case I'm showing you our persistent coverage as we tracked MEV one every night as it went from launch up to its eventual servicing of Intelsat 1002 and see a lot on the screen on but every green data point and some other object and this regime that's also being seen by our various sensors. So this continuous tracking of the client in the MEV spacecraft is required so that we can get really great fits as these other interactions between the spacecraft occur,

And I'd like to draw your attention to this part of the timeline here so just to orient you the vertical axis here is time, and we're looking near zero longitude degrees in this case. But this is where MEV to and Intelsat 1002

got close to each other, and you might say well obviously they docked, but about how close were we able to tell these two spacecraft apart?

This particular snapshot illustrates a case where we're at right roughly two kilometers. And you can see that the spots, though the point spread functions associated with the protections of both spacecraft are overlapping. This requires some additional more advanced processing to be able to get some of these astrometric and photometric measurements disentangled and associated with the right spacecraft. And we've been able to demonstrate this now down to within a kilometer.

This is important because as we apply our tools, and we analyze different interactions, in GEO, these can be a flight safety concerns in the case that we're looking at hazards as they fly by. They can be safety concerns as we're pioneering new operations in space to include things like that has been mentioned, debris removal and on-orbit servicing and maintenance, and in this case we're looking at the SJ 21 spacecraft that has admitted similar behavior of the last couple of months, I believe it went up in October, and has gone through a series of very interesting events and this one in particular has to do with its close approach with compass G2.

Video narration: On January 22nd, Chinese satellite SJ 21 showed up missing from its previous orbit slot. For a few days prior, it had conducted proximity operations with Compass G2, a defunct Chinese navigation satellite. An immediate local search failed and use of the full ExoAnalytics global telescope network was authorized to regain custody.

This video began 72 hours before the no-show event, while SJ 21 and Compass G2 are in close proximity. During this time, SJ 21 is performing small maneuvers, moving closer and closer to Compass G2. The dashed lines from Australia show Exo's routine collects. Notice the absence of collects during local daytime. The maneuver you will see occurs in the daytime gap, creating the no show condition. After the apparent docking of SJ 21 to Compass G2, SJ 21 performs a large maneuver, raising the orbit 3000 kilometers above GEO. Exo's real time network C2 and data analytics' software used in a fast turn closed loop allowed us to rapidly reacquire SJ 21, which appears to be functioning as a space tug drifting westward nearly 22 degrees per day.

We continue to track SJ 21 and monitored for conjunctions with all known space objects. The ability to maintain custody of SJ 21 after this large daytime maneuver is an important and unique capability of Exo's commercial SSA network.

Mr. Flewelling: So, as the situation is ongoing, this is how we are beginning to apply the vast array of tools that we have inside of our capabilities to observe these

operations at GEO. And so whether we're talking about transparency and definition of norms behavior and understanding the new activities that are going on at GEO, we're trying to take a data excellence approach which talks about the curation of all of the conclusions you can draw from this data and apply this to SDA.

So with that, I'm happy to take questions and appreciate your attention.

Ms. Young: Thank you so much, that was really fascinating and we have some great questions pouring in.

So to kick us off this is directed to Dan but I'd love to hear everyone's thoughts.

This is from Nathaniel Daley. How would you propose making GEO SSA data more automatically accessible to everyone, and more transparent relative to international treaties, policies, and norms?

Mr. Oltrogge: The governments— either the U.S. government or the EUSST or other government sponsored programs— have a lot of data that they can bring to bear. We showed in our STC demo how fusing that with commercial data as well as satellite operator data is instrumental to getting not just transparency but accurate solutions that one can actually use. So I think we somehow have to get that, what is that sharing and collaboration construct?

You know, the Department of Commerce is looking to have his space traffic coordination and management system. And, and that that is one aspect of it, eventually, perhaps someday we'll have enough international agreement where we can have an international, truly global system. I think that's quite a ways away. I think right now, the focus needs to be on like-minded countries working together to, to have an enable the sort of collaboration required. Thank you.

Ms. Young: Great. Thank you. Anyone else want to chime in on this question?

Mr. Becker: I can from our point of view from, I mean, I mentioned that, of course that most of our users are European satellite operators. And this is due to our legal basis to some, some extent but also mentioned the change that we're currently doing into this new partnership with increased number of member states and the and the new legal basis which is the EU space regulation.

And in fact this regulation allows us now for the first time to also extend our users to our services to users beyond here. So indeed, we're working, trying to work also with other additional users, non-European users in the past which is important for various reasons to also receive data from

them provide them with what we can see and sort of work towards that direction, and also mentioned some initiatives that we have with industry, also with other partners where we have different kinds of experiments, where we see what kinds of data would be useful to be shared for various instances being certain high alert events where it's really important to share data or other kinds of data that could be shared on a more daily basis between each other. We try to figure out what makes sense. And sometimes, even if we're all working in the same domain, we still have some different terminologies different data formats that we may be us, so it makes to foster that kind of cooperation for sure.

Ms. Young: Great, thank you, and I have another question from Bradley McAlpine. Brien, I'd love to hear your thoughts on this first is. Where do you see the future of commercial opportunity to provide SSA as a service? And to Dan and Mark, where do you see commercial operations fitting into the government systems that are already operating source?

Mr. Flewelling: Thanks. I would say our business in commercial SSA is to facilitate successful operations in flight safety, certainly above, LEO, GEO been where we focused most recently, extending past GEO to ex-GEO as I've mentioned a little earlier, but also taking observations at LEO and helping all of these operations be successful. So, as more and more ambitious operations like space logistics and things are being planned. I think it's a good idea to plan persistent observation services to help facilitate that flight safety, right. We're moving to an era where even human spaceflight is going to move from LEO out to gateway and beyond, and we still want to preserve the safety of those astronauts. That's going to require a good understanding of the different objects in space. And in the operations that are going on. So, making SSA a first class citizen of space operations, I think, is where we'd like to take this and certainly commercially that means working with owner operators and folks planning future space missions to understand what options are available right from the development of digital twins and informing that with us as a data from the very engineering processes as they're building the different phases of the life cycle for their spacecraft and then following through and providing those information services as we execute their operations.

Mr. Oltrogge: I guess I'll jump in next. You know, as I asserted in my talk earlier, the data that's available now the SSA data, legacy data is insufficient. We have to take steps to make it more comprehensive, more accurate. Because as the number of conjunctions go up. Operators are left trying to sift through all of these warnings and figure out what's actually a risk and what isn't. So the sort of accuracies that we can get Brien's company can get with 30 meters, etc. Those accuracies are going to be fundamental to keeping us from having to do avoidance maneuvers all the time.

And then, speaking to the commercial side commercial SSA is here, it's mature, it's been mature for some time. It's comprehensive, we need to, I think, figure out the mechanisms, both domestically and internationally for commercial SSA to plug into things, because I think in the past we've had a government, having a captive contractor that operates a government system.

That's not commercial SSA. That is a very good commercial government system. And I guess to add on to that, the government will always likely have the exquisite sensors, billions of dollars for a sensor. Commercial SSA is highly complementary to this because we have great capabilities that can augment and work together with these exquisite sensors to get very good coverage and performance across the board.

Mr. Becker: May I add just two proof brief points to that? Great, great points.

I think it's really important as Brien said to follow the emerging business cases new times of operations that we start to see such as removal techniques methods for removing space debris.

And this is one area where we looked into what kind of services we will be able to provide in the future and what makes sense specifically to those companies involved in those kinds of businesses. So one of the experiments I mentioned, is with Astroscale that now have their ELSA-d demo mission, ongoing and we work with them to see what kind of data, tracking data is useful for them to verify what they do and see, see how the operation is going, and for us it's important to realize what kinds of services will be needed in the next two years, giving this increase in traffic differently. Large constellations that are being launched.

And in terms of industry involvement in EUSST. We already involve the European industry in the entire value chain from sensors network processing into services. And we are certainly looking into ways to further expand that and leverage the capabilities that we have on the commercial side, to increase Europe's capabilities in SSA, and that includes those activities and new services. What can we have in terms of contributions from commercial actors, but it also includes other commercial data.

You know, we're also looking into having some kind of platform where commercial companies in Europe will be able to potentially share and provide some data that they have and we see where we have a good match with other users or they've already have in our system.

Ms. Young: Great, thank you so much and we have so many great questions I could keep you guys here for another hour but unfortunately, I think we just have time for one more. This is from Michael Madrid. For commercial operators aiming to provide GEO life extension and other servicing with maneuvering spacecraft that dock with these GEO satellites, what considerations would you want them to prioritize in their system architecture designs in the context of these SSA conversations?

Mr. Flewelling: I think being involved with providers of these SSA services early and often will help you understand where we provide the best and most precise information that that anywhere that's useful for your operation.

Interestingly, in the tracking study we did just tracking the MEV 2 spacecraft right getting down inside of that for most folks talk about five kilometers is being kind of a handoff point but maybe closer to two it really depends on the engineering design or all that. There is a point where the utility of immediate observations is limited and it hands off to the on board system in terms of final docking and closure.

And so, depending on where the handoff is, where the human on the loop processes end, and the autonomous processes begin, some of those things can be observable. And that can be very informative for folks trying to achieve these operations very safely. Also, you can work with SSA providers onboard spacecraft and provide additional vantage points from sensors and continue to do the SSA function but do it from unique vantage points to continue to extend those safety services so it doesn't all have to be done from the ground. This will end up being important for cislunar space for example as we studied recently.

So I would simply recommend to folks considering those types of services reach out to us, learn from experience. Let's make sure what we continue to maintain a very commendable record of flight safety from the very beginning as we expand out to these more ambitious operations, because we don't get to rewind it back if we if we mess something up at GEO right so making sure that we can put as many assurances in place for the missions to be successful. I think it's the goal.

Mr. Oltrogge: To add to the thoughts. I agree with Brien—please reach out to us if you're doing those sorts of operations. It's vital for that sort of operation to have the best OD accuracy, orbit determination accuracy, possible. Not just for you, your client and host, but also for anything else that's in the neighborhood to make sure as Brien showed earlier that a collision is not going to result from this.

A second thing is to support the development of and adoption of international standards for sharing your, your trajectories your

maneuvers, your points of contact, everything so that you're transparent, people know where you're going. And if they do a maneuver and you do one. This can be coordinated very closely together.

And third thing is low thrust is the tool of today, it is very efficient. But it makes SSA that much more challenging, especially for systems that don't have a non-cooperative way to solve for maneuvers. So if you're using low thrust, it's just that much more critical and this isn't just for rendezvous proximity operations. This is also for just normal operations. It's that more important to share your data be part of a collaboration to get the sort of accurate solutions that we demonstrated in the demo.

Thank you.

Ms. Young: Great, thank you guys so much. And with that, I'll hand it back over to Todd.

Mr. Harrison: Thank you, Makena. And thank you to all the panelists, that was a great discussion.

Next we're going to go to our demonstration of the satellite dashboard tool that we developed as a team.

Before I hand it over to Kaitlyn to introduce that, we do have a short video to show.

I want to be sure to thank our sponsor for this event, and for the development of the dashboard tool that you're about to see. That's the Smith Richardson Foundation, we really appreciate their support this has been a long endeavor that we've worked on between CSIS, the Secure World Foundation, and University of Texas at Austin, collaborating to bring you this tool and, and we have all sorts of future plans for it as well. But I really want to thank them for their sponsorship. So Kaitlyn, I want to hand it over to you to introduce the video.

Kaitlyn Johnson: Sure. Thank you, Todd, I thank you guys for being here today. It's been a great panel so far. I think for us the tool just highlights these activities in GEO. As Todd said we have great dreams to expand it, but it has been a long road to get here to the final site so I just want to quickly thank a couple of people before we show you the introductory video that displays about dashboard and kind of walk you through how to use it.

The first person I really love to thank is Thomas Roberts from MIT, who's been instrumental in developing this. Jacque Schrag who helped build the entire front end of the site. As well as the general CSIS iLab Team. Nevan Simone, who is part of Moriba Jah's AstriaGraph team who was

instrumental in creating the API for us to pull in data from AstriaGraph and other sources. And then just generally the team, Sam Addison, Makena Ms. Young, Brian Dr. Weeden, Todd Mr. Harrison, more of a job all of us have spent a couple years on this obviously covered through a little hitch in our plans but we're really excited to launch this to you all today.

Please visit the website. It's Googleable— satellite-dashboard.org, and Todd if you could roll the video, that would be fantastic.

(Video narration): Welcome to satellite dashboard, a new tool for visualizing interesting satellite behavior, such as close approaches from the Center for Strategic and International Studies, the Secure World Foundation, and the University of Texas at Austin. The dashboard collects and displays both current and historical satellite orbital data from multiple international data sources.

Right now, you'll find data corresponding to the satellites position at the date and time at which you visit the site. Use the date picker tool or the timeline controls along the bottom of the display to visualize space objects at an earlier or later date.

Start exploring the dashboard's underlying data by manipulating the globe visualizer using your cursor, or visiting the filter pane on the left hand side of the display.

Users can filter the space objects that appear in the globe visualizer by country, name, orbits, or several other key parameters.

Clicking the target icon next to a satellite takes you to that satellite's details pane where you can learn more about its operator status and other critical properties, such as the orbital elements that describe its position at the date and time selected in the timeline at the bottom of the display.

Use the information icon next to terms in this pane to learn their meaning, using the dashboards glossary. The Key Events tab on the Satellite Details pane reveals the satellites historical behaviors of interest. For satellites and the geosynchronous orbit old regime, like this one, this tab shows the satellites longitudinal positions over time, a key metric for understanding where it is in this machine, and what other satellites, it might be close to, followed by a filtered list of its nearest neighbors by approach distance and date.

To dive deeper into a specific key event, click the Compare objects button for objects in the geosynchronous belt. This pane features an interactive

plot of the two satellites historical longitudinal positions over time, and options to download the corresponding data for further analysis.

The last tab on the Satellite Details Pane features analysis and commentary on the object's behavior, published by members of the satellite dashboard analysis team, which offer context for the events encoded in the available data.

Anywhere on the site, users can use the pin icon to add a space object, their focus list, which can be found on the left-hand side of the display. The focus list offers users a place to save and share objects of interest.

The data that powers the satellite dashboard is automatically updated once per day, including both current locations of space objects and predicted future and close approaches. To stay up to date on the latest updates across all space objects, put the latest updates button in the bottom left-hand side at the top. This pane features the most recent historical and predicted key events.

The Analysis Tab on the latest updates pane displays the latest analysis posts published on this site, often highlighting recent or historical behavior of interest, or connecting popular news stories with the orbital element data featured on the dashboard.

Use the site's main menu in the upper left-hand corner to find archives of all key events and analysis posts, more information about the collaborative team behind this work, and details on the methodologies and key terms used.

To find more video demonstrations like this one, and the summary guide of how to interface with the dashboard, click the help button in the upper right-hand corner of the display.

Thanks for watching.

Mr. Harrison: Thank you for that Kaitlyn and great video and credit to Thomas Roberts, who narrated the video there. And if you want to check out the tool for yourself again go to satellite.dashboard.org you can check it out for yourself, but without any further discussion I want to go straight into our second panel of the day and that's going to be moderated by Brian Dr. Weeden. So Brian, over to you.

Dr. Brian Weeden: Thank you very much Todd, and thank you to the rest of the you and the rest of the crew for the work so far on this. Hello everyone my name is Brian Dr. Weeden. I'm the Director of Program Planning for the Secure

World Foundation, a U.S.-based nonprofit that focuses on the long term sustainability of space activities.

It's my pleasure today to moderate our second panel, which is going to build on the discussions we had earlier about why close approaches are challenged our current ability to visualize them. And look more at the implications of those close approaches GEO for national security and other reasons and discuss some of the various initiatives being proposed that might be able to mitigate some of the challenges arising from close approaches.

I'd like to start by introducing my panelists.

We have on your screen from left to right, Doug Loverro, who is a highly regarded national security space thinker and leader who currently serves as President of the Loverro Consulting LLC. Doug has served in a variety of very senior government positions including at NASA, where he led human exploration, in the U.S. Department of Defense where he led not national security space policy, and in multiple different department defense, and national security Space Policy and in multiple different department defense, and National Reconnaissance Office Space Program leadership roles over his career.

We also have Alessandro Cacioni. He's the Director of Flight Dynamics for Inmarsat and has been involved in the space industry for over 35 years working on all aspects of geostationary satellite operations. As director of the flight dynamics group at Inmarsat, he is responsible for orbital positioning and station keeping strategy of the Inmarsat satellite fleet.

Almudena Azcárate Ortega is an Associate Researcher in space security, and the weapons of mass destruction programs at the United Nations Institute for Disarmament Research. At UNIDIR her research focuses on space security and missiles. Prior to joining UNIDIR she was a research assistant at Georgetown University Law Center, where she is currently a PhD equivalent candidate, and she holds an LLM and national security law.

So thank you all for, for joining me for this discussion.

The way we've set this up is sort of a guided discussion of some of the various issues arising from the implications and the challenges that are derived from close approaches in the geostationary belt.

So Alex, I'd like to start with you. As was mentioned earlier in this program, a lot of these uncoordinated close approaches in GEO have been with commercial satellites, including some of the very first publicly

advertised close approaches between Intelsat, and the Russian Luch satellite all the way back in 2015. In general are these types of activities, something that commercial satellite operators are concerned about? And is that stemming from a physical collision risk is stemming from potential radio frequency interference or, or is it coming from something else?

Alessandro Cacioni:

Yes. Thanks, Brian and thanks to the previous session panel, I believe a lot I, I also think successful bringing that in my supportive to close approach of last year that was watched very closely with ephemeris.

It's a very good question. We see a lot of those warning and approaches just to give an idea for our fleet, we receive an average of anything between 15 and 18,000 messages warnings. Okay. And, as Dan also alluded to in the previous panel, having electrical Southern lights, makes it a lot harder, and I'll tell you why in a sec. But basically, we have a mix.

We've been effectively co-located within 64 days to, co-locating with Canada 25 east, we don't have any problem. Okay, we're able to set our threshold, an exchange of ephemeris between each other we know what each other and we actually within each other and don't receive any warning from that we cooperate. Okay.

Then we have those kind of uncoordinated bands to kind of approach. It happened last week.

I received from the US SDN through the 18th warnings about a possible collision, a hundred and 50 meters, believe it or not, with a US government satellite.

Okay, this was for 50, 50, 56 top six east.

It does out of these US government over there is only point two degrees apart from us. Okay, so in theory should be few hundreds of kilometers safe from the physical point of view, contact possible contact point of view. The problem is, we use electrical propulsion and even though we provide ephemeris for a month, up to a month, we have a full week span. The challenge is a that that conjunction was done using our TLE.

So, the thing using that as a network come up with a TLE can be more or less accurate that can be even up to 30 kilometers off. However, the conjunction was nine days apart and he was using our what they did use TLE provided for nine days.

Coming into collision, these satellite which was actually something like hundred and 80 kilometers away. That generated a number of obsidian warning for us.

So we need to be able to, to what I'm not saying necessarily locate the data we developed tools ourself that enable us to screen most of the data and concentrate on possible real collisions.

The example that Brien the previous panel alluded to, and improve the picture for of two, we were one and a half kilometers away from, from one of the satellite and yet we did not maneuver because we had confidence in our solution and the position of both our and, and the other satellite, so that I lot of consideration to be made.

And also the trouble with electrical satellite is the day man where every day. Okay, so if you take our satellite are mostly now electrical or hybrid where they use electrical and chemical propulsion, and we only have four satellites left with full chemical propulsion. Full chemical propulsion is simple because you maneuver once every two weeks or three weeks depending where you're at, depending on your strategy but it means is, apart from a little bit of uncertainty around the time of the maneuvering, can last up to a day or two, then there is a well known propagation, even if use a TLE or a more accurate HP or whichever kind of ephemeris, you want to provide, the solution is fairly similar. No more with electric, the fact that we maneuver every day. I produce a plan that is a minimum seven days, 14, sometimes 28, and I provide all the plan to do USSSD to the SDA and to the 18th.

The trouble is, sometimes the computation and then not using our ephemeris and that is an issue.

Dr. Weeden: So it sounds like the issue is not actually these calls approaches is the uncertainty it's the lack of data exchange the lack of coordination and just the uncertainty in the data is what's driving a lot of some of the concerns.

Mr. Cacioni: Absolutely. So that's why, even in the SSC in the Space Safety Coalition, you know, the exchange with ephemeris, the collaboration between operators is key, is possibly the most important thing. As an operator we also have sign agreement within to support the colocation we were following the same inclined profile and, and we just have a frequency separation we also decided which does meet the frequency to us not to interfere with each other so we go beyond the physical separation by we also find in agreement on the RFI, per say, and collaboration is key.

And then there is the other, the other end of the scale which is another example that happened. Unfortunately, two years ago to us. We launched the satellite in in November 19 and we were still doing the apogee sequence, to grip the GEO belt we were between the second and third burn. And, as you well know, the, the trajectory and the burn strategies

optimize to reach a particular longitude. We were going to a longitude that we had of our satellite station can be there for some time to get the right to be at that longitude. And because we performed the due diligence, we did discover by monitoring with optical observation on the ground, that that longitude had been taken up by another satellite Chinese satellite launched the month prior to us, TJS4. We wrote to the satellite operator we wrote to the Chinese government, OFCOM got involved.

We did not get a reply for six months. So that's the other end of the scale when there is no cooperation. Honestly we don't know what they really are exactly we couldn't risk to do apogee firing just locked into the longitude. So by using the knowledge that we had of this lot and with the help of of SSA provider, we found this law that was point three degrees away that was sufficient clear, physically, from this lot that we wanted to go. Not ideal, but still usable.

Yet, we may not have had that slot available to us and where do we go. So it's, it is a it is a problem.

Dr. Weeden: Great, thank you for that I'm sure we'll get into more as we get further discussion.

Doug, I want to turn to you now and focus a little more on the national security angle of this. So in addition to the commercial operators be concerned about uncertainty over where their satellite where are the satellites are keep themselves safe, there's obviously been a lot of concern from a national security sector the last several years about these kind of close approaches. Just at a high level, can you talk about sort of why close approaches might provide benefits to certain countries and also what some of those concerns are, as well?

Doug Lovero: Sure, Brian, thank you and hopefully you can hear me okay and I apologize, a little bit for my picture I'm doing my best impersonation of Elon Musk's star man. I'm sitting in my car here, circling the earth. So, Brian, I think it's very interesting, if you take what we've heard from the commercial and civil community which really centers as we've just said on uncertainty.

And then, uncertainty position. And then if you translate that back to the national defense and security perspective, uncertainty in intent. So you actually have now put together two very large uncertainties and obviously from a national security perspective, it's that second uncertainty that will resist more. As Brian and others have said, we can get pretty good at characterizing close approaches sometimes we don't get the right information from right folks, coordinate well, those are all amenable to, to much better communication and the development of tools

but the uncertainty of intent part is one that is very hard to go ahead and take care of.

So, from a national security perspective, we have been trying to be very open about U.S. intents and U.S. practices in these ways I can't tell you all those practices because some of them are classified. But I think you can get a good idea of this from how we handled the launch and operate on orbit operation of the geosynchronous SSA program the GSSAP program.

And you asked about what's the what's the national security benefit of getting close to the satellites. Well if we want to figure out what another satellite is what it can do, does it have a... to try to get towards that intent question, you have to get close enough to be able to go ahead and inspect it. And we designed the GSSAP satellites to go ahead and be able to do that kind of inspection from as far away as 10 kilometers, and indeed have operated it in all conditions where we stay at least 10 kilometers away, at least according to our calculations. Some may argue but they're not we've stayed there or not but according to our calculations we've stayed over 10 kilometers away from any other satellite.

And we not only announced when we launched GSSAP because it was a classified program, folks maybe will not recall before it was launched in 2014, it was a completely classified program. We specifically announced it and what its purpose was so there would be no mistake about it, and I think anybody who's watched the operation of GSSAP over time can tell that its operation has been 100% consistent with its purpose.

Now, there's obviously been, there are other satellites in geosynchronous orbit. We just saw a great video of them from the other panel. SJ17 that we don't know about, and that has hasn't been announced purpose that we're aware of that moves around the belt, there are other operations that going on in GEO as well. So, this intent question is really the one that has to be focused on most specifically. It is really the key to get into the national security impacts and implications of what's going on.

Dr. Weeden: Thank you that and that's as hard as the problem we just heard about just from the data and tracking, we're now adding another layer on top which is intent which is always a very difficult thing to try and assess even in land area and sea domains, let alone in in space. So that's sort of, I think, in my mind, described just how difficult this problem is even if we manage to solve the, the physical tracking of things that are 36,000 kilometers away from the earth we still might have this additional problem of measuring of defining intent.

That's really interesting. So, Almudena I want to bring it into the discussion now, because the risks that that Doug just mentioned go beyond any one country, like certainly the United States.

I know you've been tracking the reason multilateral discussions on space threats, which includes these. Is your sense that there are lots of countries that are concerned about close approaches in space, and if so, how are they describing it? What are they talking about those risks?

Almudena
Azcárate Ortega:

Thank you, Brian. And first of all thank you to the Secure World Foundation and CSIS for having me here. I've really enjoyed the discussion so far and look forward to continuing it now with this panel.

Um, so, to answer your question right: yes states are in fact worried about the issue of close approaches. These worries are not necessarily new, but certainly the more congested that space becomes, the more actors that are out there, and the more essential that space technology comes for our daily lives, the more states worry.

And this is going to sound a bit repetitive, but it's not just an issue of the technology or the risks that have already been mentioned such as, potential debris creating coalitions or things like that. But the uncertainty that these close approaches generate particularly between competitors, or adversaries.

And the space domain already suffers from a significant lack of trust and transparency between all actors. And these non-transparent or non-consensual proximity operations, or close approaches, increase this mistrust of which can escalate tensions. It can potentially endanger other space actors, and it'll actually also discourages space innovation.

And as for your question on the international processes on there is a process particularly that I'd like to highlight which was already mentioned by Audrey Ms. Schaffer in her keynote speech which is the process initiated at the UN in 2020 with Resolution 7536.

And through visits this resolution, states were encouraged t as well as non-state actors, they were encouraged to submit comments regarding what they viewed as responsible and irresponsible behaviors in space. 30 states as well as the European Union, and nine non-state actors were in which includes the Secure World Foundation as well as UNIDIR submitted comments, and these submissions served as the basis for a report by the Secretary General, which was released last summer. And both this report, and this admissions, particularly those submissions by states classify close approach operations as irresponsible behavior when

carried out without sufficient transparency or prior communication, without consent, without cooperation.

And so yes, it is definitely considered as a thing not to do by states. It should be noted however, I know that the focus of the conversation today is mostly GEO, but the concern expressed by states in the submissions and throughout this process is not just limited to GEO but essentially to any operational orbit.

Dr. Weeden: Thank you for that. It's a great point to make there about all operational orbits. I think for this event, we decided to focus on GEO in part because that is where we've had a lot of recent examples of close approaches and there's a mix of commercial satellites as well as very important national security satellites there, but you're absolutely right, the whole conversation we're having here about the GEO problem also applies to some things that are happening in low Earth orbit, as well.

Alex, I want to turn back to you, and potential solutions and mitigations. I know the commercial satellite operator community has been working on best practices and norms for operating including in GEO. Do those best practices address this issue of close approaches, including for things like satellite servicing and, which includes MEV 1 and close approach operations. And do you think that this is an area where the commercial practices and commercial norms might help influence government behavior, or at least help discriminate between different types of behavior?

Mr. Cacioni: Yes, Brian, it's a very interesting question. In my signed up to the space safety coalition, when it was formed them and contributed to these best practices. We feel that that, yes, there are IADC guidelines and then UN COPUOS guidelines international space debris mitigation then there is the ISO space system space debris mitigation and I also take form part of the ISO, in the draft of the space system space debris mitigation, but the update took eight years. OK, so the current version is 2019 the previous version was 2011. We do feel that these international standards and guidelines, evolve too slowly for how quickly the space domain is actually evolving.

Therefore, we also as done and demonstrated during the video, in the first session, cannot afford any single collision in GEO. Therefore, is not sufficient to say we are proud to say that we are the Monsanto the big operator we know what we're doing and we're doing well, because we only need one other operator we may be 180 degrees away from us, that can actually pollute the whole GEO belt for everybody. Therefore, this best practices are made available and in a more dynamic way, and is not necessarily a policy to follow but if people want to know how do I do this,

we put it in the best practice. So yes, there are indeed best practice, we advertise that overlay the exchange of information is relevant for the safety of flight collision avoidance, without the space operators.

Also the satellite or vertical selection for launch vehicles to do that to have consideration for the sustainability of the space operating environment. We also describe for those people that want to have a constellation in mind is responsible mission and constellation design to prioritize space safety, the longevity of the space, how the standard the standard ISO 24113, we speak about the probability of success will have disposal to be 90% we strive to be at least 95%.

And also, when you look at the same 24113 for LEO, it says that it should be the decommissioning 25 years we tried to make it at least within five years. We are aware that some LEO satellites are non-maneuverable therefore it's only with DK, or may con air drag change in the altitude.

However, we try to update and keep these best practices, up to date, basically, because the norm will follow too slowly for the needs that there are at the moment.

Dr. Weeden: Right then, thank you very much, and Doug I want to ask you sort of the national security side of that. First do you think these commercial norms and best practices can help with some of the ambiguity you mentioned earlier and also with the first very early on when Audrey was talking there was this notion of a incidents in space agreement. Can you talk a little bit about, for those who aren't familiar with it, what the Cold War version incidents at sea agreement was about and why a space version might be beneficial between militant talk about military here?

Mr. Loverro: Sure. And, and Brian let me before I answer those questions directly I want to go ahead and clear up something that I think sometimes we try to translate these terrestrial understandings to space and that's always difficult. You know, we talk about close approaches of space, but it's not really a distance that matters a physical length of this and it's more of an energy distance.

So what I mean by energy distance is because the and this is, this is really a question that applies a lot to the defense realm, but it also applies to, to the commercial realm, especially in the constant maneuverability we've heard about from some of the electric thrust capabilities that are on orbit these days. The energy distance is the amount of energy that an object will have to expend in order to go ahead and intersect you at some point in the future.

And, and for two for two satellites that are in our in zero inclination geosynchronous orbit, stable orbits that energy distance is actually fairly large even, even if the distance itself is small, and your two objects that are in different inclinations or even objects that are not in geosynchronous orbit but happened to cross geosynchronous orbit. That energy distance can be small.

And so sometimes when we talk about close approaches and regulating cross approaches, it is very meaningful for to residents space objects, NGOs in zero incline geosynchronous orbit or low inclined geosynchronous orbit, but from a defense perspective, we have to consider those times where there is a satellite, which is only a short energy distance away, even though it may be a large physical distance away.

A lot more complicated question for us to go ahead and regulate. So you we see everybody talks about that satellite was in a within a kilometer or so of another satellite that was a dangerous approach. Well it may or may not have been because it really depends upon whether or not there was a there was a way to close that distance in a time that made sense from a military or national security perspective.

In terms of the incidents at sea things. So, Audrey, I think answered the question, basically to say she's less concerned about the form that's such a such an agreement takes I would agree with her on that. I do think that there was the, it's important for us to understand how to go ahead and coordinate between nations, especially nations which may have different intents from a national security perspective in space and especially when it involves two national security satellites a, an a U.S. satellite and a Chinese compass beta satellite, for example, coming close approach or an SJ 17, and those kind of things.

So that kind of coordination is important. And I don't, and while, eventually I think those kind of things would be taken to the UN, the incidents at sea agreements that we had during the Cold War, are really just amongst those two, the two nations the Soviet Union and the U.S. for us to go ahead and coordinate, how we would act and see. So I don't think we need to go ahead and necessarily find out something that's going to be satisfied factory for everybody we, we know that we know the protagonists in this game. And we should concentrate on making sure that those protagonists have ways to communicate.

I was interested hear about the six month delay that we just heard about between that Alessandro just talked about in terms of the trying to get a response back from the Chinese. That's not that much different than in the national security realm as well. We don't have good, we don't have

good communications with our counterparts, on the Chinese side. And General Raymond, the Chief of Space Operations has spoken about this. He's, he was phrased it in the term of a, of a red line of a hotline or something like that. But really a way for the national security elements of the space hierarchies, to coordinate with each other, especially so that we don't misunderstand what each other has.

Dr. Weeden: That's really important. Both the lines of communication you just mentioned and then also this concept of relative energy. And just to kind of reiterate that you can have satellites that are, hundred thousands of kilometers apart in GEO, but it only takes a very small amount of energy to put yourself in a drift orbit to close that relatively easily, whereas there are other orbits where you may be coming relatively close but it takes a huge amount of energy to change that trajectory to actually collide, or come super close. And that's something that, again, because we don't, our thinking is of planes and trains and cars and we, it's hard for us to think about that but that's really the reality of the world advantage, which is a really important aspect of all this.

Mr. Loverro: Yeah, I often tell people that it's easier for two satellites to collide, that are on opposite sides the Earth going in the opposite direction, then to that are that are two that are just one kilometer apart. The, the energy distance is less, and quite frankly the timeline of closure is even smaller as well for that.

Dr. Weeden: So, I'm going to turn to the audience questions here in a minute and reminder to those who are participating, please if you have questions we've got about 15 minutes left here, we're going to try and get through as many as we can. But before we get to that, Almudena I want to turn to you one final time we'll get to the questions and, just say so we just talked about sort of maybe potential bilateral agreements on military close approaches to establish some, some safety under some norms. There's a multilateral meeting coming up very shortly. I wonder if you could sort of provide some more more details on what that is, what might be discussed there and whether or not you think there's a potential for any multilateral discussions or agreements on this topic?

Dr. Ortega: Yes, thank you, Brian. Yes, indeed. We will be having the first session of the Open Ended Working Group on this resolution that I that I that we just spoke about resolution 7536 on responsible behavior in outer space. Bilateral agreements are great, but I think multilateral agreement or talks are vital. I mean, as you probably know, the international community has had a lot of difficulties in reaching any sort of agreement regarding space security matters.

And, I mean, the current law, leaves a lot of wiggle room for states to do, essentially, what they what they want, relating to close approaches. So, initiatives such as this open-ended working group to agree on norms of behavior are really important and it's I think it's a really positive step forward. From what has been happening in the last few years. Well few years, actually, for 40 years, we haven't really seen much progress. Traditionally we've had these two teams or these two groups. One group that wanted to have a binding agreement on space security, and another group that wanted or to have something that was non-binding. And this process initiated by resolution 7536, I think has brought both of these sides closely together and closer than I think they have ever been before.

It's become apparent through this process of submitting to the Secretary General, that a lot of the concerns and a lot of the goals for states are actually very similar, but independent of which side the states are on, and these two approaches are actually not mutually exclusive.

So there is hope. At least it's my hope that through the conversations that will be had through this open-ended working group, states will create the much needed common standing and the trust that we were speaking about before t be able to agree on norms. The issues that will be discussed during this this process is yet to be determined by the Secretariat by the states that will be participating as well. But the resolution, the follow up resolution 7536 which was passed on Christmas Eve in 2021 resolution 76231, which is the resolution that convenes this open and one group, outlines four key items which is taking stock on what is already there, what laws what norms already exist. Also consider current and future threats to space systems, and on the basis of all our make recommendations on possible norms rules and principles of responsible behavior. So, it is my guess that the conversations, during the sessions of the open ended working group will surround these three topics.

As for what are the chances that an agreement involving closer produce could result from these conversations. I think, well, there are lot of things to be discussed during the sessions right. Close approaches are definitely important, they are not the only concern. So there will be lots more going on.

But from us that we went through all of the submissions to the Secretary General reports and we identified essentially four key concerns that states have. And those are the four key things that we think states will want to have norms, about on these four are space debris, the placement of weapons in space, issues that cause harmful interference in space, as well as dual use and dual purpose space objects. And I think the issue of close approaches can relate to several of these relates to space debris, if

there is a collision, harmful interference as well, and dual purpose object, objects that can do close approaches could be qualified as a dual purpose objects in a way.

So, so I think that these close approaches will definitely be part of the conversation. And from the suggestions that have already been made by states in their submissions, I think a lot of the proposed solutions or a lot of the norms that might be put forth by states will surround the issue of increasing transparency and communication to, to avoid any misunderstandings and the creation of further mistrust.

I would also like to point out just as a last remark that states are not and this has been raised up before that states are no longer the only place in space domain. Space industry makes a huge portion of space actors, currently I think it's around 80%. So industry actors have a wealth of technical know-how that they can provide to be these conversations, which is why I'm glad that this open-ended water is also open not just to states but to commercial actors and other key actors such as civil society. And I'm looking forward to how these sessions of the open and working group move forward hopefully forward, hopefully to reach solutions on all of these things that we've been talking about today.

Dr. Weeden: And I agree it's, it seems like a small step to those of you who haven't been deep into that world but it actually is a potential huge opportunity. I want to get to a couple of questions, Alex. There's a couple here directed to you I know you're, you're asking one of the chat right now but I just want to give you a chance to kind of maybe verbally address it. And it's how you might have more than one satellite at the same slot and the, the answer is partly that the ITU really regulate frequencies and broadcast at particular locations, not necessarily in those locations themselves.

Mr. Cacioni: That is correct. So, as I mentioned earlier, we were co-located with the Intelsat until a year ago at 64 east. And we also had similar frequencies so we sign an agreement with each other to know which frequency we were using as so to not interfere with telemetry. But we had different payloads.

So yes, you can co-locate at the same slot because you can, the colocation is a technique that allows you to safely keep spacecrafts at the same longitude, you effectively, maintain a different eccentricity evolution and inclination evolution. You control your longitude but you don't see it.

So if you divide in the x y plane into four quadrants, as long as you keep your eccentricity in one quadrant and the other one in the other quadrant, then, then you maintain a physical separation of 20 kilometers effectively, even though you both have zero degrees inclination and you

both within plus or minus 05 and longitude. So that's technique for co-location which can be used. So why should they effectively limit the number of satellites that can occupy slot, because we can coordinate.

Dr. Weeden: And again we're to remind ourselves we're talking about, even in the same slot is 10s of kilometers wide, which, as long as there's some tracking and a sundry a coordination, you can put a bunch of satellites in there from a physical standpoint.

Mr. Cacioni: Correct, correct. And then that's what some of some of the leaders do because they only have one slot, located to them and they put one more subtle one or more satellites in there. And all you can share this lot, we have a lot that we are sharing with Helisat. So there is only I was a lot of 59 degrees east, and then we put one of our satellite at 39 degrees east and we effectively are co-located with the Helisat but we use different frequency. So yeah, it's not a problem here.

Mr. Loverro: Brian, this is, this is Doug I just add something about it sometimes when we talk about and apologize for my video being off but I had to start driving down from where I was and so I don't want you to see all the flashing sunlight coming through. Sometimes we forget just how, just how big geosynchronous orbit is right and you just mentioned, for example a slot (*static*) kilometers for even for even high frequency, or even cave, and it could still be a 10 kilometer slot and that's it. It's fundamentally a cube in space and if you can think about two cars separated about by 10 kilometers at the, at on a huge desert pane, that is a large distance.

In, in any space, the problem is we don't, we can't unless we're there cooperate with each other, our uncertainty is most of the distance between them. And Brian, I think I gave a great, a great example of just how low we could shrink that uncertainty when we really try, but still the uncertainties are still measured in kilometers.

Dr. Weeden: That's a great point. Um, and I want to, I want to close here with the question that's where the top of the queue here. And I think for the interest of time, I'll take this one for to give some of the backstory there so Almudena mentioned that is part of the process for this UN resolutions 7536, countries were submitting what they see as potential threats to space and space security what to do about it. And in China's response they, they mentioned the MEV 1 and specifically, they, they talked about how the repeated tests of the USX 37b spacecraft, the use of MEV1 to extend the life of a commercial communication satellite, and then the deployment of the U.S. military's counter communication system, which can be used to jam satellites from signals, and that all these technologies can be diverted to offensive military use.

So I think that's a, that's an interesting and not quite apples to apples comparison. Two of those systems that were mentioned there the X37B, and the CCS are explicit military capabilities.

Whereas, one of them the commercial MEV which docked other commercial satellite is a purely commercial capability. I mean my sense I don't think this is something that is directly comparable. But I will just say that this gets to what we've talking about, is the importance of providing transparency to be able to discriminate between those military capabilities and activities and educational activities in this case. Kudos to Inmarsat and Northrup Grumman, because for MEV it was well-advertised ahead of time, this is going to be happening, they talked about this is the satellite we're going to be rendezvousing with, they were sharing data with all the other operators in the neighborhood and they've been fairly transparent about that whole process so I think that was really important.

I want to please everyone please join me virtually as you can't we can't see or hear you but joining us and thanking all of our speakers from this from this whole panel and Todd, I'll turn it back over to you for closing remarks.

Mr. Harrison: Hey thanks Brian, and yeah I just want to reiterate my thanks to everyone all of the speakers at this event. This is a very, like, very enlightening discussion, we're able to get really deep on some of these topics I think you're an increasingly important and thank our audience, there were a lot of great questions I saw coming into the Q & A. I wish we could've gotten to all of them but we will keep the conversation going in future events like this. So thank you all for joining us and I look forward to seeing you sometime in the near future. Bye everyone.