THE BROOKINGS INSTITUTION

WEBINAR

SPACE JUNK - ADDRESSING THE ORBITAL DEBRIS CHALLENGE

Washington, D.C.

Wednesday, May 13, 2020

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Moderator:

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P R O C E E D I N G S

MR. ROSE: Good morning and welcome to today's Brookings webinar, Space Junk - addressing the challenge of orbital debris. My name is Frank Rose and I'm a senior fellow here at the Brookings Institution and I'll be the moderator for today's event.

The topic of today's discussion is how to address the challenge of orbital debris, more commonly known as space junk. Decades of space activity have littered earth's orbit with defunct satellites and pieces of orbital debris. Indeed, experts warn that the current quantity in density of manmade orbital debris significantly increases the odds of future collisions, either as orbital debris damages space systems or as colliding debris creates more debris. And because of the high speeds these objects travel in outer space, 17,500 miles per hour, even a sub-millimeter piece of debris could cause a problem for humans or robotic space missions.

Therefore, a key question facing the United States and the entire world community is how to address this growing challenge in a way that ensures the long-term sustainability, safety, security, and stability of the outer space environment.

Luckily, we have two experts with us today to help walk us through this very complicated issue. First, we have Dr. Jer Chyi Liou, NASA chief scientist for orbital debris and our other panelist is Ms. Victoria Samson, Washington office director for the Secure World Foundation.

That said, let me explain our agenda for today. We'll begin the event by having J.-C. walk us through the technical issues of associated with orbital debris, specifically, what orbital debris is, how it got there, and why it is a problem. Following J.-C.'s presentation, I'll then ask Victoria to discuss the policy response to the orbital debris challenge. After that, I'll ask J.-C. and Victoria couple of more questions and then turn to some questions submitted by the audience.

If you would like to ask a question you can do it one of two ways. You can email us at Events@Brookings.edu, that's Events@Brookings.edu, or you can tweet us at #SpaceJunk.

With that, let me turn the floor over to J.-C. for his presentation.

J.-C., the floor is yours.

MR. LIOU: Good morning. Thank you, frank, for the introduction.

The first human made satellite was launched in 1957. Space activities since that time

have polluted the near earth space environment with orbital debris, which has become a threat to the safe operations of space missions.

The biggest objects in orbit are being tracked by the DoD's Combined Space Operations Center, the CSpOC. There are approximately 23,000 object 10 centimeters and larger. NASA uses additional ground based radar periscopes and (inaudible) measurements to characterize debris too small to be tracked by CSpOC, but still large enough to threaten human space flight and robotic missions.

Our estimate for debris one centimeter and larger is about 500,000. For debris one millimeter and larger, the population is estimated to be on the order of 100 million -- 10 to the power of 8. The average impact speed between two orbiting objects in low earth orbit is about 22,000 miles per hour. This is more than 10 times the speed of a bullet. Because of the high impact speed, even a small piece of debris could cause a serious problem. As a matter of fact, mission ending threat is dominated by small millimeter-sized orbital debris.

In terms of mass, the amount of material in space has exceed 8,000 --

MR. ROSE: Excuse me, J.-C., it's Frank. We can't see your presentation. You might want to double check and make sure the presentation is up. Sorry.

MR. LIOU: Okay, so let me try that again here. Can you see that now?

MR. ROSE: Yes, all set. Go ahead.

MR. LIOU: Okay, very good.

So in terms of mass, the amount of material in space has exceeded 8,000 metric tons. So this chart shows the historical increase of objects in earth orbit. The top curve is the total and the population breakdown is represented by the four curves below the total.

Fragmentation debris, the purple curve, has dominated the population almost from the very beginning. The two big jumps in the fragmentation debris population are due to the Fengyun 1-C anti-satellite test in 2007 and the collision between the retired Cosmos 2251 and the operational Iridium 33 in 2009. There are about 2,000 spent rocket bodies; many of them are more than 1 metric ton in mass. Of the more than 5,000 spacecraft, only 2,100 to 2,200 are operational.

The orbital debris problem is twofold, long-term and short-term. The long-term problem is illustrated by this chart, the history of mass in orbit. Despite decades of efforts to limit the generation of

new debris, the mass in orbit continues to go up. There is no sign of slowing down. This really underlines the potential of a collision cascade effect, the Kessler Syndrome.

As Frank mentioned earlier, the mass increase will lead to more accidental collisions which will generate more debris to trigger even more collisions down the road. Good policies, guidelines, and best practices to limit the debris population increase have been established since 1995, first by NASA, then U.S. government, and the international organizations, including the United Nations. The problem is the global space community is not doing a good job following the existing best practices. A good example is the 25 year post-mission decay limit, the 25-year rule.

The technical community has long recognized that effectiveness of using the 25 Year Rule to limit the debris increase in low earth orbit. For example, if there is a 90 percent global compliance with the 25 year rule, then we can reduce the debris increase over 200 years from the more than 300 percent, the top red curve, down to 110 percent, the blue curve.

The difference between the red and the blue curves highlights the benefit of the 25 Year Rule. However, in reality, the global compliance level is far less than 50 percent. The take away message here is that the global space community must improve compliance with existing orbital debris mitigation best practices. That is priority number one.

Some have suggested to shorten the 25-year rule, but from the difference between the blue curve and the purple curve, you can see that the benefit of reducing the 25-year rule to 5 years is not very significant.

Will limiting the generation of new debris, which is mitigation, be enough to address the long-term orbital debris problem? The answer is no. Eventually we will need to consider remediation, active debris removal of objects already in space, especially the old spent rocket bodies and retired spacecraft, to address the long-term orbital debris problem.

From the environment management perspective, both mitigation and remediation are needed. Just like the pandemic we are facing today, we will need both prevention and cure. In terms of urgency, efficiency, and cost effectiveness, the current priority is mitigation. Orbital debris is a serious problem, but the sky is not falling. We do not need active debris removal today, but we must develop enabling low cost technology and techniques in preparation or remediation in the future. This has been

the position of the United States government, as reflected in the 2010 National Space Policy and the 2018 Space Policy Directive-3.

For satellite operators, they are facing a different problem, a short-term problem, which is the threat from orbital debris to their operational spacecraft. As I mentioned earlier, the orbital debris population follows a (inaudible) size distribution, meaning there is far more small debris than large debris. As you can see from this (inaudible) size distribution of the debris population, crossing local orbit, there are about 10,000 debris larger than 10 centimeters, about 250,000 debris larger than 1 centimeter, and tens of millions of debris, 1 millimeter and larger. When the 10 centimeter or larger debris impacts an operational spacecraft, the outcome is the catastrophic breakup of the vehicle, which is bad. When a one millimeter debris hits an operational spacecraft, the outcome may not be catastrophic, but the impact can penetrate the fuel tank, cause problems to batteries or pilot critical components to terminate the mission early.

Because there are far more small millimeter-sized orbital debris than 10 centimeters and larger debris, mission ending risk is driven by many millimeter-sized orbital debris.

Conjunction assessments and collision avoidance maneuvers against the large tracked objects only account for less than 1 percent of the mission ending risk from orbital debris.

Satellite mission ending risk is driven by small millimeter-sized orbital debris. That is a fact recognized by the safety community. Unfortunately, we do not have measurement data on the millimeter-sized orbital debris to properly characterize the risk in key orbital regimes, including altitudes between 600 and 1,000 kilometers. Why is that important? Today, there are more than 400 spacecraft operating between 600 and 1,000 kilometers, but there's a lack of direct measurement data on the risk driver, the millimeter-sized orbital debris in that region.

There is a critical need to collect measurement data on such small debris so that we can use the data to improve orbital debris impact risk assessments to support the development and implementation of cost effective protective measures for the safe operations of future space missions.

Here is my summary. How do we measure risk from orbital debris? The goal of space traffic management is to enhance the safety, stability, and sustainability of operations in the space environment. For space traffic management, if safety is a priority, then orbital debris is a priority. If safety

is a priority, then addressing risk from small orbital debris must be a priority to better protect space missions. There is a critical need to improve the space situational awareness on small debris.

For long-term environmental management, the global space community must do a better job to comply with existing orbital debris mitigation best practices to slow down the debris population increase. Then, at the same time, we need to establish long-term goals, combining mitigation and remediation to preserve the space environment for future generations. Thank you.

MR. ROSE: J.-C., thanks for that great presentation outlining the challenges of orbital debris. Victoria, now the question goes to you. What do we do about this big challenge? Over to you.

MS. SAMSON: Well, J.-C. talked so much about possible solutions, and I have to agree with a lot of them. I think there's going to be no one silver bullet in how do we fix the orbital debris problem. We're going to have to have a variety of approaches, remediation and mitigation are both incredibly important.

But I think we need to recognize that the space domain has devolved over the past several years and that our governance needs to evolve with that.

The 25 Year Rule was fantastic and has done a lot to help establish priorities for debris mitigation, but I don't know if necessarily reflects where we're going in the future. You know, we have mega constellations that are going to be launched. Right now, as J.-C. said, there's about 2,200 active satellites current over that much. With the mega constellations we're going see possibly 50,000 more launched. Probably not all of them, but you're going to see a huge increase in the number of satellites being launched. And I think, you know, there is potential for, you know, inactive satellites within that bunch. We need to figure out ways in which to take down debris as needed that's created, but also try and limit how long the debris is up there.

I'd be curious to know, NASA did their analysis of debris mitigation and looking at the 25 Year Rule and that there wasn't that much of a difference, but I don't know that it keeps in mind all the costs for the five Year Rule versus the 25 Year Rule. With all the debris up there you have a lot of operator costs in terms of discussing conjunction approaches, you have operator costs in terms of moving around satellites to prevent collisions, you have space situational awareness concerns. And so I think it's a really complicated issue that requires a whole of government approach.

Right now, that we're working under the 2010 National Space Policy from the Obama administration, as J.-C. explained, it calls for DoD and NASA to work together to research and look at active debris removal. Right now we don't really have a government agency that is charged with this responsibility. And I think that's probably one way in which we need to go about doing that.

As well, we still have some disagreements in terms of who's in charge of space situational awareness. J.-C. said it's national, and I absolutely agree with him on that. There are some disputes between the administration and Congress which agency should be involved in it. I think they just need to pick someone and move ahead.

But, you know, in addition to that the industry is taking a leadership approach in terms of how to think about this. And I think that's really important because while space historically has been the domain of nation states, the commercial sector is getting to be increasingly important. We're seeing specifically, again with the launch of the mega constellations, those are not government entities launching them, that's commercial. That's entirely commercial, which means that space as a domain will become largely commercial in the future. And so if you want to have effective policies, you need to make sure all of the stakeholders are involved in the conversation.

I will say the Space Safety Coalition, which is a conglomeration of about 30 plus space actors, (inaudible) has signed onto this, has a suggestion about best practices and norms of behavior, and one of the things they do call for is aspirational (inaudible) 5 years on orbit after satellites are done with their mission. But, again, that's aspirational.

So I think it's interesting to see what's going on. We also have the FCC that has come up with some suggestions for orbital debris mitigation. And those of you familiar with our governance in space works, FAA is -- you need to get a license with them to launch, you need to -- the FCC has to give you -- in order to broadcast you need to show the FCC you have orbital debris mitigation rules. And then if you're doing remote sensing or earth imaging, you need a license from NOAA. And so FCC has to get involved in this conversation.

So I think, again, that indicates that there is a recognition by the U.S. government that this is important. We just need to coordinate within the different agencies and government branches how we go about doing this. And again, to show leadership in (inaudible) and how to go ahead in doing this.

MR. ROSE: Great. Thanks so much, Victoria.

J.-C., let's build on one of the points Victoria raised in her presentation, and that's the issue of mega or large constellations of small satellites, like SpaceX's Starlink system. You know, my understanding is that SpaceX is planning to place a constellation of 42,000 of these small satellites in orbit. Wow. On top of that, other companies have plans to place similar constellations in orbit.

From your perspective, how big of a problem is this? And what steps should be taken to ensure that these large constellations are deployed in a way that won't undermine the long-term sustainability of the space environment?

MR. LIOU: Well, Frank, thank you for the question.

One unique aspect of large constellations is the mass production of the spacecraft based on the same design and build process. So if there is a flaw in the design build or test process of the spacecraft, as you can imagine, the problem can propagate too many spacecraft. Once launched, it is impossible to recall tens, hundreds, or thousands of spacecraft from space.

So the key to mitigate potential orbital debris issues from large constellations is to ensure very high quality and reliability of the large constellation spacecraft.

Let me just give you one example. In local orbit, depending on the number and mass of the spacecraft, as well as the orbital lifetime and the background debris environment, 99 percent post-mission disposal reliability may be necessary for some large constellations.

Regarding SpaceX, SpaceX should be commended for the recent decision to lower their first generation spacecraft, as you mentioned, more than 4,000 spacecraft from 1,200 kilometers to 550 by 40 -- by 70 kilometers altitude. At such a low altitude, because of the strong drag force in the atmosphere, any failed spacecraft will naturally decay and reenter in less than 25 years. This means they can achieve (inaudible) percent of mission disposal success.

And because of the low altitude, most fragments generated from the breakup of the spacecraft would also reenter in less than 25 years.

So if you operate a large constellation at a low enough altitude, the long-term negative effect to the environment can be mitigated.

MR. ROSE: Thanks, J.-C. Victoria, anything you'd like to add on that point?

MS. SAMSON: Yeah, I'd like to emphasize a little bit what J.-C. said earlier about compliance, because I think that's really important, compliance of the debris mitigation guidelines and the lifespan rules.

We see better compliance at geostationary orbit, but as J.-C. mentioned, at low earth orbit it's maybe 60 percent. And sometimes it's just because a lot of the satellites re-orbit naturally, they have a natural decay and they come back down quickly. In terms of active re-orbiting, you don't see as much of that.

And so I think it really is important to emphasize that it needs to be followed out strictly by these mega constellations, especially because we will have, no matter what -- I don't care how careful you are -- there will be some failures. And if you have a-- you know, right now I think the failure rate of constellations is maybe 5 percent, and so when you have a constellation of maybe 42,000 satellites, that's a huge number. You need to figure out a way in which to go about doing that. And I think it's really important for that.

The other thing that I would also emphasizes in terms of the importance for debris removal when you all these major constellations is that we've already seen it happen OneWeb. Some of these constellations, these companies, they're going to start and they're not going to be around in the future. So who's going to be involved in making sure they comply with debris mitigation, you know, in the future? So that's why I think it's really important to have that kind of capability there so we can come in case there's no one to really follow through from a commercial viewpoint.

MR. ROSE: Great. Thanks very much. Victoria, let's go to you now. One of the issues that I've been following very closely is China's rise in outer space. From the perspective of shameless promotion, I just wrote a paper on this issue, which you can find on the Brookings website. Indeed, China's 2007 anti-satellite test, as J.-C. noted in his presentation, is responsible for a lot of the debris in low earth orbit. And China is continuing to expand its space activities, both on the civil and the military side.

So, Victoria, what should the United States be doing in cooperation with China to limit the growth of orbital debris? And how would you assess the Trump administration's overall approach to working with China on sustainability issues to date?

MS. SAMSON: Well, you know, that's a tough question, Frank. Your excellent paper talked about the U.S.-China relationship and space security issues -- sorry, I got muted for a minute. I recommend people who are interested in this to read your paper and learn a lot from it.

But China is difficult because we don't know what to do about China in any sector, much less space. The United States is prohibited via a law from Congress for having bilateral discussions with China via the White House or NASA. If they want to they have to get a waiver, but they can do multilateral discussions.

And so I think it's really important to try and have some of those multilateral discussions. We've already done a lot of work with China at the UN Committee on Peaceful Uses of Outer Space. We discussed long-term sustainability guidelines. There has been some effective work there. And I think also there's a recognition that a responsible space actor does not deliberately create debris on orbit. China was roundly criticized in 2007 for doing its ASTA, anti-satellite test, that created the debris on orbit. I think they learned a lesson about how not to go about doing that.

But I'd also like to emphasize as well in terms of debris on orbit, the most amount of mass of debris in orbit is actually created by Russian rocket -- spent rocket vehicles. And so it's important to understand that for an issue that's as complicated as orbital debris, we need to work not just with the U.S. allies, but competitors -- or however you want to describe Russia and China. This is not easy, but it's really important to go about doing that.

I know that the U.S. has had bilateral discussion with China on space security issues. I would encourage us to keep on doing that, to keep the communication, the lines of communication open, and to see about ways in which we have similar interests, because, you know, one of the things I always argue for China is I think it's actually encouraging that they're putting so much money and effort into their space programs and their space capabilities because that's an incentive for them to try and make sure that domain is stable and predictable and available to them.

You know, they're working under the same laws of physics we are, they have a lot of the same budgetary constraints. And so, you know, they don't want to mess up an environment that they put a lot of their eggs in one basket, so to speak. So I think that's an incentive to find commonalities for issues and goals for us both to work on. As two of the major space powers, I think it's incredibly

important that we find a way in which to coordinate some of our concerns.

MR. ROSE: Great. Thanks very much, Victoria.

J.-C., anything you'd like to add?

MR. LIOU: No.

MR. ROSE: Well, J.-C., let me come to you and talk about the issue of active debris removal. You mentioned that in your presentation, but I'd be interested, are there some promising technologies out there that could perform this mission? Is this mission, you know, five years ago, twenty years away? What's your thought from a technical perspective?

And, Victoria, I'd be interested in hearing your thoughts on the policy implications of moving up into space and grabbing pieces of satellites. I always like to say, one person's debris removal system is another person's anti-satellite system.

So, J.-C., let's start with you.

MR. LIOU: Thank you, Frank. Again, that's a very good question. When considering active debris removal for environment remediation, cost is the major concern. Currently there are about 5,000 spent rocket bodies and retired spacecraft in space and many of them are several metric tons in mass, up to, close to one metric ton each. For meaningful remediation we may need to remove most of them from the space environment. It is really cost prohibitive based on today's technologies. Many groups have proposed concepts on how to remove debris, however, until a very low cost solution is identified, environment remediation is not realistic, it is only a nice concept.

Thank you.

MR. ROSE: Victoria?

MS. SAMSON: Yeah, I agree with J.-C. Right now it's hard to find a business argument for rocket removal in low earth orbit. We're seeing some of that happening in geo. (Inaudible) did something earlier this year. And there's been promising technologies I think with regards to that. But all the policies issues still need to be worked out.

As you mentioned, Frank, there's concern about intent, you know. If you're going to be active debris removal, what is your intent, how do you get a close approach, how do you signify that what you're going to be actually doing is intended to be maintenance as opposed to something that's more

malevolent. And that's where having policies that actually spell out, okay, how do you do close rendezvous and proximity operations in a way in which it's not threatening others. That's really important.

I will say there's an organization called CONFERS, the Consortium for Execution of Rendezvous and Servicing Operations. It's funded by DARPA. But it's a consortium of about 35 different solid operators, commercial, who are talking about different ways in which they can do rendezvous and proximity operations --and Secure World is part of this well -- where they're trying to figure, okay, what are the best practices that we want to promote, what are the norms behavior. I think that's been very helpful to kind of put it out there because then you can try and figure this out for everyone. You know, we're really -- as I said before, this space domain is really changing and evolving and we're just figuring out the rules as we go along. And sometimes activities in orbit are getting ahead of the governance issues.

Other things to keep in mind is liability. You know, who's responsible if you move some debris and it causes some sort of damage, who is going to be paying for that. It's always a big question because, again, as I said before, and as J.-C. said, there's no real business model currently at the cost structure in low earth orbit. And so -- but you can argue, you know, this is a public good, perhaps this is something that government should be paying for. So of course the next question is well which government should be doing that. You know, to be honest, the United States is responsible for 30 percent of the debris up there, so we're going to probably be on tap for some of that, you know.

So it requires thinking about this. And then also, how do you -- if you get close to debris and it's someone's satellite, how do you go about letting them know, okay, I'm going to take down your debris? Do you need to get their permission? Is it consensual? So there's a lot of questions to figure out and we're just in the early stages of looking at this. But I think it's really important to start thinking about that.

So once the technology is there, and the technology is very close to being there, the policies will be there as well.

MR. ROSE: Great. Thanks so much.

Well, let's move to the questions that we've received from the audience. The first question comes from Travis Cotton (phonetic) from the Institute of Defense Analysis and it's about space traffic management.

Victoria, in your statement earlier today you mentioned that the Trump administration would like to move the mission for SSA or space situational awareness and space traffic management from the Department of Defense to a civilian agency. And the rationale is given the emerging threat from Russia and China, DoD needs to focus on the military mission and a civilian agency should deal with the SSA or space traffic management mission.

The question I have for you is twofold. One, do you think transferring the mission from DoD to a civilian agency is the right call? And, secondly, is the Department of Commerce the right agency to transfer the mission to?

MS. SAMSON: It's a great question, Travis.

And I think it hits on some of the difficulty we have in discussing these issues. I mean just for some background, DoD has been involved in the space situational awareness or tracking objects in orbit, and this is vestigial in terms of why they're doing it. It's a remnant of the Cold War actually. DoD was monitoring Poles -- the North Pole frankly -- to see if there were Soviet ICBMs coming over the horizon, and while they're doing that they said, oh, yeah, we should probably -- we're seeing other stuff, let's just keep on that, take a look at that. But it was really secondary in terms of that capability. And then there used to be not as much up there to keep track of, and so it was fairly easy, I think, relatively speaking to keep track of things. But it was -- I hate to say explosion when you talk about things in orbit -- but with the increase, the vast increase of objects on orbit and users in orbit and satellites in orbit, it became much more complicated and I think it became -- it was taking away from the national security mission. And so DoD has been open to the idea of someone else taking on that responsibility in terms of at least civil communications for the commercial sector and agencies and that sort of thing.

And so Space Policy Directive-3 announced in June of 2018 tasked the Department of Commerce with having this responsibility and that builds onto Space Policy Directive-2, which basically wanted to make Commerce the one stop shop for all sorts of regulations.

The issue you run into is that Congress -- I mean the administration can say what they want, but Congress has to actually give them the authority and the money to do this sort of thing. Congress is not entirely on board with it being Commerce. There's still some factions within Congress who want the FAA to have this responsibility. And then at one point I heard the FCC was throwing their

hat in the ring. I don't think that's much the case anymore. But it's still not certain which civil entity is going to be involved in this. I am relatively agnostic. I don't care who it is. I think both agencies would be great, but someone needs to be tasked with responsibility and funded accordingly. That's always the key thing, right, in government. You can say what you want, but unless the money's there it's not actually going to do anything.

And so I think it's really important if they decided that they really -- you know, if Congress signs on board and they want Commerce to have this responsibility, then they need to make sure that the Office of Space Commerce gets appropriately funded.

MR. ROSE: J.-C., anything you'd like to add on that point?

MR. LIOU: Yes. So NASA is not a regulatory agency, but at NASA we do have a tremendous technical capability in orbital debris environment definition, risk assessments, space situational awareness, and space traffic management. So we are prepared to support the Department, Commerce, or DoD to develop standards and best practices for space traffic management.

MR. ROSE: Great. Well, we've got a lot of questions about anti-satellite tests and norms of behavior. I'm shocked.

So we've got one -- let me go through them and then we can -- I'll turn it over to you two to provide a response. First we have Nick Ropa (phonetic) who mentions that last year in March India shot an anti-satellite test in outer space which created debris. Furthermore, John Hermaso (phonetic) from Manila University wants to know would present space law be -- is it effective to regulate or even outlaw ASATs given their threat to space exploration? Or do we need new rules? Cathy Colwell from the U.S. General Accounting Office asked what are the international implications of these types of events? And Paul Flahive, of Texas Public Radio said what international policies have been proposed or considered that seem promising, if any?

So I guess of all of those questions, the fundamental thread is what norms should we put in place to help prevent the occurrence of further debris generating anti-satellite testing?

Victoria, would you like to start?

MS. SAMSON: Sure, I'd be happy to.

So talking about anti-satellite tests, or ASAT tests, during the Cold War both the United

States and the Soviet Union had a couple dozen ASAT tests, but we both kind of unilaterally agreed to hold off and do a moratorium on testing just because it was perceived as incredibly destabilizing. There are no actual -- right now there's no legal prevention in the Outer Space Treaty for doing an ASAT test and the Outer Space Treaty prevents having weapons of mass destruction in orbit or on the moon.

So in theory, if you're just doing a kinetic ASAT test, you'd be doing a direct intercept or direct hit and create debris in orbit, in theory that is legally possible. You could argue Article 9 in the Outer Space Treaty requires prior discussions about things that could affect the space environment. A lot of people don't really use that too much.

So I think the key point here is talking about what you said about norms, Frank. The United States had its last ASAT specifically in 1985. It was launched off an airplane. And then there was nothing until 2007 when China did its ASAT test. And, as I said, it was criticized roundly for that sort of behavior. And then in 2008 the United States had a satellite that we argued was de-orbiting in an unstable way and it needed to be shot down. (Inaudible) argued it was done as a response to the Chinese test. And so we shot it down. But we did it at an altitude that was low enough that didn't create large amounts of debris, we were pretty open about it and that seemed to set the standard that okay, you can have an ASAT test as long as it's low enough to create a minimal amount of debris. And so China had a couple of different tests after that. They said it was a missile defense program, but basically they were testing with the same interceptor. And, you know, they said well, it was low enough debris, it's not really causing an issue.

And so when India had their test last year, they made the same argument. They said, look, we're doing this in a manner that's -- the altitude is low, the angle is low, it's going to create a minimal amount of debris in orbit, so it should be okay. And actually it was at a low altitude and most of it has de-orbited -- the debris that was created. But there is still some out there and it's not a non-event.

And so my concern is that what we're seeing is a norm being established that it's okay to have an ASAT test as long as it's low enough orbit and the debris is pretty minimal and it de-orbits pretty quickly. Now, you might say, okay, well that sounds pretty good to me, why is that an issue. I mean at some point what you're doing is you're normalizing the idea that ASATs are okay and that ASAT tests are okay and you're going to see a proliferation of ASAT capabilities. Secure World has a counter space

threat document we put together that talks about counter space capabilities. It's available on our website. Also our good colleagues at CSIS has a counter space threat document that's also excellent, talks about these issues. And what we're seeing is it's becoming almost -- well, maybe not a rite of passage, but importance for a space power. It's not just enough to be a major space power if you want to have global influence, it's not enough to be able to launch your own satellites, it's not enough to have a space agency, now it's almost seeming like you need to have a space force or you need to have an anti-satellite capability. And we're seeing that sort of thinking spreading and taking hold. And at some point someone is going to want to use those capabilities in a hostile environment. And that's where it can be very destabilizing. You can see it escalate very quickly and then you have an orbit that's, you know, littered and rendered functionally unusual for possibly many years. It has long-term consequences.

MR. ROSE: J.-C., anything you'd like to add?

MR. LIOU: Yes, Frank. Regarding ASAT tests, as of today close to 100 countries operate satellites in space. Since we share the same space environment, any new debris will affect everyone, every satellite operator, period. Therefore, from the orbital debris mitigation perspective, any potential break up leading to the generation of a large amount of high altitude (inaudible) debris should be avoided. So from the environment preservation perspective, we should avoid intentional destruction.

Thank you.

MR. ROSE: We've got a lot of interest in this whole issue of active debris removal. I've got a great question here from Larissa Penhoe (phonetic) of Northwestern University. Larissa asks, collecting space debris involves high cost. As a public good, how do we capture value, i.e., profits, so private parties may be interested in hiring space debris companies? How do we turn collective benefit into a private benefit capable of generating profits?

Who would like to take that one?

MS. SAMSON: I could start, J.-C., if you want to finish. I mean that's the eternal question of a public good, you know, who pays for this sort of thing. Really and truly, how do you make sure you -- the profit eventually is there for someone to have an incentive to go about doing it. I mean really what we've seen in the past, you know, for these public-private partnerships is that the government needs to be a foundational support in these sort of capabilities. And it goes into a big discussion you

have about what exactly is private sector, you know, versus public sector in space. You know, because if the government is the sole customer, is it really considered to be private sector.

But I think the fact of the matter is if this capability needs to be there and we need it to be able to function in space, I argue that the government should find a way in which to pay for this sort of capability just because, again, it is a lot of money to spend now, but when you're looking at the tradeoff in terms of how much the space sector brings to our economy, I think it's incredibly important, particularly under this administration, which has couched a lot of their decisions on space in terms of how it affects the commercial sector. I think it's really important to find a way in which to cover those sort of costs and then to make sure that the private sector is properly incentivized with a so called light regulatory touch. They're acting in a responsible manner but they're not having onerous regulations. It's a fine line to walk and it definitely is challenging, but it's been done in other sectors, it can be done here.

MR. ROSE: J.-C., anything you'd like to add?

MR. LIOU: Yes, I just would like to say that for meaningful environment remediation -- and I underline meaningful -- for meaningful environment remediation, it is not enough to move two rocket bodies here, (inaudible) spacecraft there. For meaningful remediation, we may need to remove thousands of metric ton class (inaudible) and retired space craft.

And so really, as of today, even the global space community, it is not clear to me that with today's technology the global community can afford to do that. We afford really the keys to continue to encourage and support the development of potential low-cost solutions that eventually will be able to do it sometime in the future.

MR. ROSE: Great. Thanks.

Let's stay on this issue of the private sector and the private sector's expanding role in space. We have another question and the question is, with the increased proliferation of commercial space situation awareness capabilities and services, do you see the government investing less is space situational awareness sensors similar to the space vents (phonetic) in the future and relying on commercial providers?

Who wants to take that one?

MS. LIOU: I can go first. So for space situational awareness, I would really repeat what I

emphasized during my presentation. It does not matter who is leading the effort -- government, commercial, really the key is to improve the safe operations of future space missions. Regarding space situational awareness, we must focus on the high priorities. Yes, improving the accuracy of tracking and conjunction assessment is important, but at the same time, space situational awareness of small millimeter-sized orbital debris cannot be overlooked.

MS. SAMSON: Yeah, I'll just add onto that. I mean I think definitely it's an opportunity. The commercial SSA sector has grown so quickly. They've got a lot of capabilities that perhaps are on par or even better with what the U.S. government has. The fact of the matter is how do you coordinate between U.S. government sensors and commercial sensors and, you know, sharing data bases across classified domains. I mean that's going to be challenging, but I think it's important to be able to figure out how to use that because they do provide different capabilities and they have different sensor types. Again, the U.S. government SSA network that came out of the Cold War, still ours in mostly in the northern hemisphere oriented towards monitoring things coming from the then Soviet Union, where the commercial SSA sector is evolving their -- you know, they have a different emphasis.

So I think it's important to start tapping into those resources. You see that a little bit with the National Geospatial-Intelligence Agency. You know, they're using commercial sensors in a way in which to help enhance their knowledge of what's going on on earth and using those as opportunities to do that. So I think they've been very forward thinking. I would encourage the rest of the U.S. government to be as well.

But it's not just the commercial sector, there are a lot of international SSA capabilities that are growing. The Europeans have that, other entities have that, Russia, China, India, Japan, they're investing in SSA capabilities. And so truly to have a strong SSA network, it's important to have all these modes of information.

And I would last like to end, of course, information is only as good as what you can do with it. And so when we would be able to analyze it and get the information out in a timely manner to owner operators so they can respond quickly. And that's where I think it's important to have all these different modes of input because then you have more accuracy. And the concern, of course, with all these different mega constellations and new satellites coming up, and possible debris in orbit, is you're

getting all these conjunction warnings. And so what do you with that sort of information, how do you depend upon what's useful and what's dependable. And so having confidence in this information is going to be important. And the only way you can do that is by increased transparency.

MR. ROSE: Great. The takeaway that I have from that series of questions is that when it comes to SSA, cooperation with the commercial sector, with international partners, and others is going to be key. This is not a mission that the United States can do on its own. It requires strong collaboration and cooperation.

Okay, we're coming toward the end of our session here. We're going to do one more and then I'll give you each a couple of minutes to kind of sum up and say anything you wanted to say, but haven't had a chance.

The last question is from Matthew Feldman (phonetic) of Magnet. Matthew asked if and when a piece of space debris damage a private satellite, what will happen legally? Will we have private companies suing countries for damages? And what if that country no longer exists, like the USSR?

MS. SAMSON: Okay, I'm not a lawyer -- a caveat of that -- but it's my understanding the Liability Convention would be invoked here. But for the Liability Convention to be invoked you need to have an idea of where the debris coming from, whose satellite created it, and we just don't know that a lot of the time. Sometimes we do, a lot of the times we don't. Let's say we do, we have to say, okay, did that country sign a Liability Convention and, you know, go on from there.

The Outer Space Treaty Article 6 requires continuing supervision of national activities in space. And so that means countries are responsible for space activities from their citizens, whether or not they're government agency or they're commercial sector, or they're academics, or what have you. And so that's why there's a real incentive to make sure that countries are on board with debris mitigation guidelines and rules and that they're carrying them out at the national level through regulations or however you want to do it, because in the end countries are going to be responsible for these sort of capabilities.

And then in regards to countries that no longer exist, I'd have to double check on this, but it is my understanding that Russia took on a lot of the obligations from the former Soviet Union, but put an asterisk after that. I'm sure my space lawyer friends will all be emailing me as soon as this over and

correcting me on that one.

But I think it is important to recognize that there are responsibilities in orbit and that's where countries need to take the lead in terms of discussing at the multilateral level how are we going to go about agreeing with these norms of behavior and getting involved in this conversation.

And the last thing I want to add to that is that often times when we discuss this issue people are like, oh, insurance, that will be the solution. Let's just make everyone have a lot of insurance and they can cover it. Space insurance usually covers the first, you know, launch and maybe the first six months of a satellite's life and after that not many people carry insurance for that sort of thing. The insurance sector is very conservative and so they haven't really stepped out to do anymore efforts and don't particularly have a lot of interest, frankly, in my understanding of increasing their involvement in this just because they don't make a tremendous amount of money on space insurance.

So I don't think insurance will be the solution. I think we really need to have agreements at the international level how we want to go about this and who's responsible for paying, and then make sure that those agreements are nationalized via regulations at the domestic level.

MR. ROSE: Great. Thanks so much, Victoria.

We have four minutes left, so let me go to J.-C. to see if there are any final comments he'd like to make to sum up.

J.-C., the floor is yours.

MR. LIOU: Very good useful (inaudible) discussion.

Orbital debris is a global problem. It would require global effort, government, commercial, international organizations to work together to address the problem. As we move forward, we need to pool resources, corroborate, and focus on high priorities to address the short-term and long-term risk from orbital debris to better preserve the environment for the safe operations of future space missions.

Thank you.

MR. ROSE: Victoria, any final remarks you'd like to make?

MS. SAMSON: I mean J.-C. said it so well. I agree with him on all of that. I would just like to add as well, again, as our use of space is evolving, our governance for space needs to evolve as well. How we go about doing this, we need to bring in the commercial sector in these international

discussions, which is often challenging because these international discussions are held on the multilateral level and, you know, frankly typically the commercial sector is not involved in that. We need to coordinate across interests. So it can't just be the U.S. and its friends and family, it needs to be all major space stakeholders.

The other thing that we haven't discussed so much is we need to make sure when we're sharing information and working together, often times space capabilities, especially at the national security level, are classified just automatically. And that really puts a speed block in front of these international cooperation discussions. And, again, that may have made sense years ago, but now that anyone with a telescope, or even a good camera phone can see satellites in orbit, it doesn't make as much sense to have that automatic classification of objects in orbit. And so I think we need to really rethink how we approach classification of our catalog and how do you approach sharing information across raised catalogs, whether they're commercial, government, academic, or international in nature.

MR. ROSE: Great. Thanks very much, Victoria.

And that I think is a really important point on classification. I think the good news on that point is that the U.S. Department of Defense appears to recognize that. I've seen statements from General Raymond, the chief of space operations, as well as General Hyten, the vice chairman of the Joint chiefs of staff, who have talked about the need to declassify that information. So it seems to be working its way through the system.

On that note, we are at the end of our time. I have really enjoyed this discussion. I hope our audience has learned some new and interesting facts. I certainly have.

Let me thank both Victoria and J.-C. for taking their time to be with us today. And let me also thank the audience for joining us at today's event.

Have a great rest of your day and stay safe. Thank you so much.

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