Event Transcript: Summit for Sustainability
Summit Opening and Spotlight Talks
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Krystal Wilson: Hi, everybody. My name is Krystal Wilson. I am the Director of Space Applications Programs at the Secure World Foundation for those of you who don't know me. I also happen to be the Summit Chair for the first ever Summit for Space Sustainability. Obviously, I want to start with thanking you all for being here.
When we talked about this idea internally last year, we really feel that the time has come to take advantage of all the hard work that our organization and numerous others have done in the last 10 to 15 years to raise the profile of space sustainability issues, everything from security to new actors, to space law, to orbital debris.
We think people understand that this is a topic that we need to focus on. You can't go to a space conference today and not hear about those things. We also think that there are needs to be even more happening to make progress on bringing all of the different actors together in order to actually work on these problems, to make commitments and define solutions that we can all agree on.
As an example, just yesterday, we brought together some of our speakers and a few other high-level stakeholders to spitball how can we seed some ideas for this conference, what can we be thinking about, where are the opportunities?
I got their permission that I wanted to tell a little story. One of our biggest goals for this conference is to bring together different groups of people within the space community and without.
At Secure World, we go to a lot of different things. I personally am really involved in a remote sensing and application world. My colleagues are part of the security world, and on and on. You go to these, and we talk to each other. Even in the space community, we're very siloed. We think one of the most important things to making progress on space sustainability is to start to break through silos.
I couldn't even more pleased yesterday [laughs] when Mr. Andre Rypl the Chair of COPUOS came to me and said, "Hey, just had a great conversation with [inaudible 2:06] from Iridium and we think he needs to come present on their experiences -- I think we all know what experience I am talking about -- as well as their current activities today."
To me, that's exactly the kind of connections that we want to make here. Not only to encourage you to, obviously, sit and listen the talk, but we want this to be engaging, we want this to be interactive. If you have any feedback for us, please let us know.
We have an exciting and thought-provoking lineup. You have your agenda. Let us know if you have any question. Right now, there are no changes. I'm probably jinxing myself.
A couple of logistics reminders, we aren't going to be doing too many live questions. We will be involving the slideshow question tools. When we get to that portion of the program, you'll be able to log in using the information that you see on the screen, to provide our panelists and speakers with questions.
They will be moderated, so we will try to just pick a couple of questions. We are pretty time limited. We wanted to squeeze in a lot of information over the next day and a half. We'll pick a couple of questions per section, and ask those questions. I encourage you to vote so that we have a sense of what's most interesting to the audience.
Really basic stuff, bathrooms are over that way, exits are marked. If there's an emergency, we will proceed in an orderly manner to the exits, and follow the National Press Club staff. I also want to remind everyone this is a

public event. There is media present. We will have photographers in and out. We are recording with hopes of posting online for posterity sake and research.
If you have any questions about that, please see one of the Secure World staff. Same thing, if you have any problems at all, any questions, any concerns, find someone who says, staff. We know most of you, so I don't really think it should be too difficult. Do let us know if you have anything that we need to deal with.
A reminder as well, that we do have a code of conduct online. If there are any problems or complaints, please see me as the summit chair, and I'll be happy to help you with that. Finally, I want to thank our sponsors. This is something new for Secure World. We have a lot of partnerships, we work with a variety of organizations.
When we decided that we wanted to have an event that really focused on all of the areas of space sustainability, we knew it was important to reach out both to media partners and traditional sponsors and say, "Hey, we aren't the only ones that care about this." We want to bring together like-minded folks to say, "We all really need to work on this."
I'm really pleased to have Space Logistics, OneLab, ISSA, AGI, Virgin Orbit, and Astroscale as sponsors for this event, as well as media sponsors of "Apogeo Spatial," the Global VSAT Forum, Space News, and "SpaceWatch.Global." I think this kind of breadth and depth of interest in this topic, really shows just how important it is to all of us. Thank you again to our sponsors.
Now, I'm going to introduce Dr. Peter Martinez. For those of you who don't know, he's our new executive director after a long and fruitful search last year. We're excited to welcome the former chairman of COPUOS' Scientific Technical Subcommittee, the working group on long term sustainability of outer space affairs.
We'll talk more about that if that's unfamiliar for you. He comes to us as the professor of Space Studies at the University of Cape Town, Peter.
[applause]

Peter Martinez: Thank you, Krystal. Good morning, ladies and gentlemen, colleagues, friends. It's wonderful to see so many acquaintances here in Washington, DC. Welcome to all of you. Welcome to this first Secure World Foundation Summit on Space Sustainability.
It's my great pleasure and privilege to welcome you all here this morning. As you see, the title of our summit is...it says, "Summit for Space Sustainability."
I want to emphasize the word for because the aim of our summit here is to contribute to the development of solutions to address the multifaceted and multiscale problem that we refer to loosely, but with the words space sustainability.
What is space sustainability? The term space sustainability has now entered into common use, at least in the English speaking space community. It has emerged rather recently, within the last 10 years or so. It's widely used. It means slightly different things to different people.
The last UN summit of the 20th century was the UNISPACE III conference held in 1999, 30 years after the Apollo 11 moon landing. It's interesting to note that in the Vienna Declaration on Space and Human Development, which was the high level political outcome of UNISPACE III, the phrase space sustainability does not appear even once. There are a few references to the contribution of space to sustainable development on Earth. That, in itself, was an important step forward and helped to promote the development of space activities worldwide for reasons other than national prestige or defense.
The Vienna Declaration contained a few references to the anthropogenic threats to the space environment and the importance of preserving that environment through space debris mitigation measures, the avoidance of radio frequency interference, and the safe use of nuclear power sources in outer space.
The Vienna Declaration also touched on natural threats emanating from the space environment itself such as near Earth objects and space weather.
In the decade that followed, the UN Committee on the Peaceful Uses of Outer Space and many states began taking action to address these various aspects. Indeed, in the first decade or so of Secure World's existence, many of our activities focused precisely in these domains. Indeed, a number of them still do.

Space sustainability, like its terrestrial counterpart, is a multifaceted and multiscale problem. I mean multiscale both in the spatial sense as well in a temporal sense.
As the pace of space activities and the number of space actors grows, new facets to the sustainability debate appear. There are now facets to this problem that were not even imagined in 1999. The Vienna Declaration contains one reference to "the growing contribution of the private sector to the promotion and implementation of space activities."
Curiously, it was made with regards to the role of the private sector in helping the UN to promote the exploration and use of outer space or to support the recommendations of UNISPACE III in developing countries.
That's it. Let's fast forward another 20 years to 2019. There's now a much, much greater number and diversity of space actors than there were in 1969 or even in 1999.
We're seeing the emergence of large numbers of non-state actors, and also the development of new kinds of space activities that would have been considered in the realm of science fiction, but which are today either already in the realm of science fact or soon to become science fact.
Today, the global space economy is roughly worth $400 billion, of which 80 percent of that is commercial activity. There are projections that this could grow to a one to three trillion dollar economy in the coming decades.
A lot of people are thinking about how we're going to get from where we are today to that trillion dollar economy. One thing is certain. It's not going to happen with a business as usual approach to how we plan and conduct space activities.
It will require us to think about how we behave in a space environment that is much more crowded and contested than it was in 1969. The pace of developments will require us to shift from academic debates to real world policy debates, but in a context where there is still significant uncertainty about what might be the most effective regulatory approaches to adopt.
A case in point is space traffic management where there are still significant differences of opinion as to what it actually means, whether it should be approached top-up or bottom-down, and how to go about creating a workable regime.
I can cite other examples, but the point is that we are now in a situation where the various space sustainability challenges are known, and what we need to do is to move from academic analyses and debates to policy oriented discussions to deal with these challenges. That brings us to this conference.
The aims of this conference are twofold. Firstly, to present the full scope of Secure World Foundation's activities, and secondly, to discuss those issues where policy discussions need to be advanced and where we need to develop potential solutions.
The breadth of Secure World Foundation's work and the extensive network we engage with means that you may know some of our projects but not all of them. Some of you may know us best for our work on the development of norms of responsible behavior for commercial actors.
Others may be more familiar with our work in multilateral fora that focus on strategic stability in the space domain and on discussing transparency and confidence building measures. Still others among you may know us for our work on maximizing the use of space applications for socioeconomic benefits on Earth.
All of these efforts are united in their focus on addressing the many challenges that threaten our collective ability to access, use, and benefit from space now and far into the future.
That is the mission that drives our work at Secure World Foundation. During 2018, we completed 120 activities in over 20 countries on 6 continents. These activities are outlined in our annual report, which is available on the tables by the registration area.
With regard to the development of potential solutions for emerging space sustainability challenges, the space sustainability policy debate is now a much richer and more complex debate than simply worrying about space debris, radiofrequency interference, and space weather effects on satellites. The issues of sustainability, space safety, and space security are intertwined.

Take for example the growing number of possibilities for access to space and the emergence of a host of new on-orbit capabilities, many of which are driven by non-state actors. What does this mean for space security, space safety, and the strategic stability in space?

We're all aware of the range of challenges to space sustainability brought about by the emergence of new space actors and new types of space activities. Many of the new technologies and capabilities have great potential to enable new areas of on-orbit commercial space activities, but they also raise concerns for the safety, security, and sustainability of space activities.

There is a widespread acknowledgement that the existing governance framework needs to be complemented with new norms of responsible behavior.

The question is what kind of norms do we need to have the most impact on space sustainability. What kind of behaviors do we want to encourage or discourage? Who should develop these norms? Once these norms are developed, how will we be able to encourage their wide implementation?

Lastly, what are the respective roles of government, the private sector, and multilateral institutions such as the UN in the creation and socialization of these norms?

Speaking of the UN, last Friday, the UN Committee on the Peaceful Uses of Outer Space formally adopted by consensus of all 92 member states the 21 guidelines for long-term sustainability of outer space activities and a politically significant context setting preamble, these consensus guidelines will be referred to the UN General Assembly a few months from now.

This is probably the most significant output of COPUOS in the past decade and a significant step forward for promoting space sustainability. This output is based on the inputs gathered from international experts over a process that lasted eight years.

I emphasize the importance of having experts' inputs in the development of these international norms. As we go forward, the role of the commercial sector will be even more important than it was in the first round of the COPUOS LTS discussions.

Secure World Foundation strives to be at the forefront of identifying emerging policy issues and creating dialogues among key stakeholders to advance policy thinking on these issues. We see measures to promote space sustainability as an enabler, not as an inhibitor of space activities.

Examples include our work on human and environmental security, space policy, and space law in the role of the private sector in the development of norms. One example I would like to cite is the need for norms for close proximity on on-orbit servicing operations.

Secure World Foundation is helping to address this challenge through CONFERS, the Consortium for Execution of Rendezvous and Servicing Operations, an independent industry-led forum created to advocate and promote the satellite servicing industry and encourage responsible behavior for responsible commercial, rendezvous, and proximity operations on on-orbit servicing.

Since its formal launch in May 2018, CONFERS has grown to include 28 industry members from the USA, Canada, Japan, the United Kingdom, France, and Germany, and has published its first guiding principles and it's currently working with ISO on an international standard for satellite servicing.

Secure World Foundation is also working to raise the salience of the space resources development issues. Since 2015, we have participated in The Hague International Space Resources Governance Working Group.

The working group, which has more than 30 members representing government, academia, and civil society from across the globe will propose a set of building blocks for an international framework on space resource activities. These building blocks set up the basic principles and issues that should be considered in the development of adaptive governance for space resources utilization. As we become more reliant on space systems and as the commercial sector becomes more heavily invested in space activities, there's a growing concern over the proliferation of counterspace capabilities.

Because such activities are often shrouded in secrecy, it is difficult to hold open well-informed debates on the topic. To support an urgently needed open debate, SWF developed an assessment of global counterspace activities based on open-source information and published its first edition in April 2018.

This report is unique in that it covers in one publication all the counterspace programs of which we are aware worldwide. Copies of this document are available on the table at the back and also on our website.
At Secure World, we aim to remain at the forefront of emerging space sustainability policy issues, hence our decision to organize this summit. Space sustainability is a long game that requires commitment and focus for extended periods, especially when one is working in policy areas that require multilateral work where progress is made at the pace of the slowest actors.
I want to acknowledge my predecessors, Ray Williamson and Michael Simpson, who charted and then stayed the course of SWF over the past 15 years. As in any long journey, midcourse corrections are required to adapt to changing circumstances.
This conference will help us to chart the way forward and to keep us on course towards maintaining outer space as a safe, sustainable, and secure space environment for all space actors.
I have no doubt that new issues and challenges will emerge, ones that we can't even foresee today. I'm confident that we will be able to address those challenges through the development of appropriate normative and regulatory frameworks that involve public and private sector actors and through international cooperation.
In closing, I would like to thank all of you for attending this important event. We would like to thank all of our keynote speakers and our panelists who will be sharing their thoughts and insights and experience with us over the next two days.
We also thank our sponsors, without whom this event would not have been possible. I would also like to thank the National Press Club for availing their facilities to us today and the summit chair, Krystal, and the other Secure World colleagues for all their planning and hard work over the past year to put this summit together.
Last but not least, I would like to acknowledge and thank our president and founder, Cynda Collins Arsenault who's here with us in front, who had the foresight to organize the importance of finding cooperative solutions to ensure space sustainability, for her inspiration, her vision to establish Secure World Foundation, and her outstanding leadership of our board.
I wish all of you an exciting conference and an interesting exchange of views over the next two days. I think this is what Krystal referred to spitballing. I'm still getting used to these American terms.
[laughter]
Peter: Never heard that one before. Thank you very much.
[applause]
Krystal: Thank you, Peter, for the introduction to what we hope to accomplish as well as what Secure World does on a day-in and day-out basis.
I'd like to begin now with our Spotlight Talks. These are envisioned to set the tone for the rest of the conference. We have a variety of panels and keynotes who will be offering their thoughts on very specific topics.
Before we did that, as I mentioned earlier, we hope this is a mixed room. We hope we have space people, non-space people, and just a little bit of everyone here. We thought it was important to really lay out the foundation of what we mean by space sustainability and the various aspects of it.
I'm going to invite our first Spotlight speaker, Mr. Holger Krag from ESA, who will be giving a speech on the state of the space environment.
Holger Krag: Thank you very much. Good morning, everybody. I thank the Secure World Foundation for inviting me to speak.
I'm the first speaker, so I have to play the role of the messenger who brings the bad news. The title is "State of the Space Environment". It's very short because the environment is in a bad state.
[laughter]
Holger: I guess you want to hear a bit more. I will start out as follows. What you see here is the situation today. Every dot represents a manmade object that has the size of at least one meter.
These objects have a size that we can well track regularly from ground. We know these objects. We know them by name. We know where they are. Even better, we know where they will be tomorrow. This is data we can use in operations. They are about 6,000 of these out of there.

We move on. Now what you see here are all objects that are larger than 10 centimeter. Now we have a number of 35,000 objects roughly, significantly more.
The white dots that have been added are actually not intact space objects that are physically in one piece. They are really fragments or parts thereof due to more than several hundred on-orbit breakups and fragmentation events that have happened so far. I will come back to that.
Still, 20,000 of them are regularly tracked by the powerful surveying systems here, in particular in the US, from ground. We use this data in operations.
We move further. What you see now are all objects above the size of one centimeter. We are talking now about the number of 900,000. I could continue forever like that.
[laughter]
Holger: We stop with one millimeter. Here the number is 130 million roughly. That is our estimate. We can't see all these objects anymore from ground. They're far too small. We can do reasonable engineering assumptions and modeling to guess this number.
What do they mean? All these objects in space naturally have a high velocity to keep their orbit. On average, that's 25,000 kilometers in an hour in LEO, which means in case of a collision, you can have, in principle, double of that at impact, 50,000 kilometer an hour.
Even though one centimeter object by that would mean a mission loss, one millimeter object impact on your satellite would still mean significant damage, up to the loss of a payload. That's why I don't stop at one millimeter.
If you go down further, our model continue work still for these low diameters. Solar cells get impacted with plasma generation and electric discharging effects. It's still notable in fact. On optical surfaces, they would suffer even from the impact of micrometer, dust-grain size object. Even small objects matter at these high velocities.
Where does the problem sit more precisely? This black line gives you the distribution of manmade objects over altitude. Of course, space doesn't stop in 2,000 kilometer altitude where the diagram stops. The problem becomes significantly less in higher altitudes.
There's another interesting region is the geostation region which I will leave out because the biggest problem at the moment is in this low Earth orbit.
There, even at the lowest Earth orbits, you can identify one region of particular concern. That is 800 to 900 kilometers altitude which is an altitude which is very precious to all of us. That's where our Earth observation satellites on polar orbits' flying, on sun-synchronous orbits.
You see it gets a bit cleaner when we come down to the altitude of the Space Station, 400 kilometers. That's not because we are polluting less there, mo.
[laughter]
Holger: It's because the Earth atmosphere is helping us to clean out the environment. In this altitude, 400 kilometer, the Earth atmosphere is producing still so much air drag that the object would vanish by themselves within just one year. It's also the reason why we have to boost up the Space Station twice per year, to keep the altitude.
In 600 kilometers, it would be around 25 years. In 800 kilometer, the remaining lifetime would be around 200 years. In 1,000 kilometers and above, it would be basically forever. Atmosphere has no more effect there. If we had no atmosphere, the diagram would be looking completely different. The pollution at 400 kilometer would be similar as in 800 kilometers.
Right on the top of the peak in 800 kilometers, ESA also flies a satellite called Sentinel-1A. That fleet of sentinels is just operated next door. One day, they came and said, "Look, it seems like we got a hit from the side overnight. Satellite changed its altitude. It also looks like it has been thrown back on its orbit. On top, we have lost a few watts of power."
What we did then is, "Look, let's use the camera we have been using for monitoring the deployment of the solar array right after the launch," which you see on the left side, "Let's invoke that again and take another picture." They did this.

They found this circular feature on the solar array. The solar array is big. The circular feature has a diameter of 40 centimeters. That's massive. You can do the momentum balance. You can find out what the size of the object would have been. It's about a few millimeters, far too small to be tracked from ground and completely impossible to avoid by collision-avoidance maneuver.
That came from behind and caused that impact. You see the other side of the damage here. The surveyance network now starts tracking fragments that have been caused by this impact. These fragments are large enough to be tracked.
They now have already triggered several conjunction alerts with other Sentinel spacecraft. That shows already quite nicely how entangled the problem is up there.
How did they come there? Let's take a look at the history of the object that I call catalog. These are those that are regularly checked since the beginning of spaceflight. The dark blue ones are those that are still on orbit. The light blue ones are those that have been ones on orbit and have in the meantime decayed. Looks there's more decay than still on orbit.
Also, of course, atmospheric reentry is an issue. If you count all the numbers together, you end up with 40,000 that have been on orbit and that half of them have reentered. In terms of mass, it's even the majority. We have 8,000 tons of mass in space and more than 20,000 tons have reentered.
If you put all the reentered object by their size next to each other, you get an area that corresponds to roughly 20 football courts. That's a massive amount. We should not ignore that as well.
You see a significant change in the trend in 2007 and 2009 which is due to just two singular events. One is the antisatellite test of Fengyun 1C in 2007. The other one is the Iridium-Cosmos collision in 2009.
Let's take a look in the future. The launch rate is giving a good indication of what is likely to happen. These are the number of objects launched into the low Earth orbit since the beginning of spaceflight. You see it used to be a constant number of 100 per year roughly, quite constant, only a few deviations.
In the past two years, we have quadrupled this to 400. That will further increase if you look at plans that might be easily reaching 1,000. This is a dramatic revolution. There's a revolution in spaceflight that is going on here that we have never seen before. Of course, that can intensify the problem if we don't do that properly.
What are we doing wrong? Why did we have more than one hundred or several hundred fragmentation events on there? Spacecraft and rocket stages are built for operating a functional mission. They are not built to withstand very long in the environment after operation.
When you switch off your satellite, many things happen. You lose the nominal altitude. Sun is shining on faces of the satellite that have never seen sunlight before. A component heats up. They are impacted by microparticles, atomic oxygen.
It's a very aggressive environment out there. They are not built for that. Initial residual fuel, residual pressure in the tanks can lead to these breakups. That has happened.
The more frightening message is we are aware of that and we have passivation measures in our guidelines, meaning releasing fuel, discharging batteries. We get rid of all the energy onboard to avoid this. It's still happening. In the past decade, there are still 50 events happening. That's something on average between 5 and 10 per year still happening.
Why is that? Are we careless? No. We are implementing passivation in our spacecraft. We fail. Even with good intent, we can fail.
There's another thing that happens. We still suffer from the past. If you take, and that's just a random example, the DMSP satellite series came very famous recently, because that is a series of satellites that have been launched more a decade ago, nine spacecraft.
All of them will break up, because the battery design that was used had some runaway problem sometimes even during operations.
Here, you see the time when they have been launched. These are the blue triangles. The red ones are the time when they broke up.

They were broke up while they were operating, a couple of them, but then the rest of the series was launched, and now still breakups are happening, because they can happen much, much after the end of operation. They can happen after the whole of the series has been launched.
Two are still missing. We know they will still break up. There's a lot of heavy touch we have on the past. Some design flaws, they will only become apparent after years in space. This is only a small series, but imagine this to happen with a series of several hundred spacecraft. That would look very bad.
There's another guideline out there since many years, and that is to dispose your spacecraft from low Earth orbit, use your propulsion system to lower the altitude so you would automatically disappear from space within 25 years. Are we actually doing that?
These guidelines, my lawyer friends, they always call it the soft law, because they are not binding law. They are made law by sometimes being referenced in national regulation, but they are de facto soft laws.
When you have a soft law, you also need to soft-police, to follow up what's going on. That's what I try by making transparent in how we actually behave. I look into the surveillance data and do statistics on how many of us have done it.
The green bars are the good guys and the blue ones are those that fail. At least the trend is positive, but of course, number of 30 percent of all missions successfully implementing post-mission disposal is not enough.
If, and that was the dream of the technical experts -- the IDC -- we were implementing all guidelines, the trends that you see here would look different. This is a trend in the growth of objects from the current 20,000 for the next 200 years if we did nothing, if we just continued spaceflight as we do before.
That wouldn't even account for large constellations. It's just the traffic of the past repeating would look like that.
If passivation would work perfectly -- it doesn't, I've shown it, it doesn't -- because of several technical issues that we have to overcome, it would be half of the game. Half of the fragments we have in space now are explosion fragments. That would mean a lot.
If we did this passivation perfectly and we would do, not even perfectly, but to 90 percent, the post-mission disposal to account for some failures, we would have almost a flat trend. That would do the job, if it only worked.
If we are not happy with a flat trend and we want to revert the situation, you would have to do active removal, which we all know is a big effort, but it would help to even improve the trend.
If the 30 percent continue to be done and the explosions still happen at the current rate of five or more per year, the trend would look like this. It's a continuation of what we are doing now, would almost look like doing nothing.
We need to get much better. It's not only a problem of missing information [inaudible 34:10] and guidelines, but it's a question on implementing it.
Final slide, it is that we are not only watching it, but we also want to do something about it. Therefore, we have set up a very ambitious space safety program, which will address various elements. Space debris has a focal point, has a very, very important role in this program.
We will continue tracking objects. We believe that's not only more surveillance data we need, we also need better one. We need higher quality. We are maneuvering our spacecraft because of false alerts, which goes back to insufficient quality in the data. We need to get better laser, could be a way to get there.
We would like, for the first time ever, to successfully remove an object from space, which is already a piece of debris now. We know already which one it is. I can't tell you, yet, but that will be the one to be removed.
It's more than 100 kilogram large, and we want to do it by 2025, asking a service from an industrial provider, in other words, having a market perspective of that kind of service already in mind. That's part of our program.
We would like to help everybody operating spacecraft in the environment to overcome the workload of collision avoidance, automating it, making the decision shorter. Let machines decide, and let centers automatically coordinate on maneuvers.
Finally, we need to help our industry to follow the guidelines in a competitive environment. That means they need technology. We need to be able to remove a spacecraft from space even perhaps after loss of contact so that it autonomously does so, and that also passivation sequences can be executed without human control in the case of a loss. We need this technology to improve the trends.

Thanks a lot. That's all.
[applause]
Krystal: Thank you so much for getting us started on exactly the most useful way to really look at the problem, look at the facts. We can't really talk about what we want to do unless we really understand where we are. Thank you so much for that.
Our next speaker will be speaking about the globalization of space. What does new entrants look like? What does it mean around the world? Who is entering into these domains?
We'd like to welcome Rogel Sese from the Philippines and Regulus SpaceTech for our next Spotlight Talk.
[applause]
Rogel Mari Sese: Thank you, Krystal. Good morning, everyone. I am Rogel Sese from the National Space Development Program, the Philippines. I wear multiple hats. Basically, I am the one who is in charge of pushing for the space program in the country.
Looking around at this room, I see that I am one of the very few representatives of an emerging space nation. The perspective that I will be bringing here in this summit might be a little different from the perspective of established space nations.
Over the past 50 years, when we look at how space has evolved over time, we can see that the number of countries that have satellites currently in orbit has greatly increased. In the 1960s, it's only about less than 10 countries, but now we have more than 60 countries that are actively operating satellites in space.
In the UNOOSA, according to the registry of objects, there are more than 4,000 satellites in orbit, and 2,000 of them are currently active. This shows how space has evolved over time or the past five decades.
This is something that, when you look at this image, you can see that a lot of the countries right now are emerging space countries who are trying to get into having their own space programs by having CubeSats, microsatellites, launching them from space. This poses an issue as well for space sustainability for everyone else.
However, when we look at the distribution of satellites launched per country -- this is coming the Union of Concerned Scientists -- you can see that almost all the top players who have active satellites in space are not coming from emerging space nations, but are actually coming from established space nations.
I think it's only Argentina here who is considered to be an emerging space nation with about 14 satellites. This shows that despite the number of satellites that we have in space, the role that emerging space nations have played in terms of launching satellites in space is still relatively small.
When we look at the number of active satellites, this has significantly grown in the past five years. In fact, it has almost 500 satellites just in the last five years alone. This is a progression that we are expecting to continue over the next decade. This shows us how everyone, not just established space nations, but also emerging space nations, should be concerned about space sustainability.
On the legal side, when we look at the global status of the Outer Space Treaty, we can see that almost all the major players are party to the Outer Space Treaty. However, most of the emerging space nations, including us in the Philippines, are either just signatory or did not even ratify or sign the Outer Space Treaty.
This is important for us, because if we want to ensure the sustainability of the space environment, we have to make sure every upcoming new player, new space actor, whether it's a government -- especially if it's a government agency -- should be aware of their responsibilities with regards to ensuring the safety of the space environment.
Just in the last five years alone actually, we have about eight new space agencies who became operational. We have the Polish Space Agency, Australian Space Agency, UAE, Bahrain, New Zealand, Turkey, and even Portugal. We can see that the trend right now is more and more countries are becoming involved in the space program. This is very true all over the world.
I think one of the newest or upcoming -- this is something I would like to announce in this forum -- one of the upcoming newest actor in the global space community is actually the Philippines.
We are actually now on the verge of creating our own Philippine Space Agency. We are just waiting for...
[applause]

Rogel: Thank you. Just this month, earlier this month, Congress and Senate passed the Philippines Space Agency Act, and we are now just waiting for the signature of the president to formally create it and establish. That would come within the next 30 days. We are going to be the youngest space actor now in the community.
When you look at why do developing countries have a space program, most of the time, the reason is actually more about prestige, making sure that they look good, whether it's to their citizens or to the international community. Having a space program has a very big value and it can boost the country's morale.
On top of the prestige aspect, most of these countries are also looking at the applications of space technology to militaries. When you look at the history of space, militarization is very much intertwined with space development. This is something that has to be a little bit of...we need to be a little bit more concerned.
As these countries would evolve over time, we can see that their perspective changes a bit. It's no longer about having prestige, having applications in military, but more of having application that is contributing to their national development and much more longer -- 10 years down the line -- they are now also being concerned with having independent access to space.
I think this is where emerging space nations should take note of and learn from the experience of established space nations, that we need to be concerned about the security of the space environment and space sustainability, not 5 years down the line after having a space program, not 10 years down the line, but right from the very beginning.
This should be in the forefront of what national space program should be concerned with or involved. Taking a look at the region where I come from, my country of Philippines, which his part of the Association of South East Asian Nations, these are 10 different countries.
Out of these 10 different countries in the region, 8 of them have their own emerging space programs.
I think right now, it's only Brunei -- 8 or 9 -- that doesn't have a formal space program.
Everyone else, from Indonesia to Thailand, Malaysia, even Myanmar, Cambodia, everyone in the region is having their own space program. This is a population of about half a billion people in the world.
I think this is one very crucial region in the space community that in our region alone, we need to get our act together to ensure that we can work with everyone else and ensure the cooperation agreements, not just with each other, but also with our established space nations.
When you look at another reason why emerging countries are going to space, when you look at the comparison of the number of satellites versus the economic ranking in the ASEAN region, you can see that having access to space technology is directly correlated to the economic ranking of a country.
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This is very much evident in the South East Asian region, the more satellites that a country has, no matter the size, the greater the economic ranking. When you look at Singapore, which is the smallest country in South East Asia, and Indonesia, which is the biggest country, it's not a matter of whether a country is big or small. It's a matter of also about having a number of satellites.
Then you have the mid players -- Malaysia, Thailand, Vietnam, and the Philippines. Then you have the bottom players -- Myanmar, Cambodia, Laos, and Brunei. You can see that this is a trend that we are expecting to continue. We are doing a similar analysis for other regions in South America and also in Africa to see whether this is valid or not.
In terms of distribution of satellites in the ASEAN region, most of these countries in our part of the world are concerned about Earth observation and communication. Every now and then, we also have a lot of technology-demonstration satellites.
These are microsatellites, CubeSats that are launching from the ISS, which eventually after a year or so, they're already deorbited, so in that aspect, it's not a bit of concern.
When you look at emerging space nations, this is actually where we come from. Our main issues as emerging space nation, we don't have a lot of technical resources and capabilities compared to emerging space countries. That is the reason why most emerging countries focus on building CubeSats and microsatellites, because that is the only thing that they can afford. That is the only thing that these countries would have access to.

The second aspect is the lack of awareness on space sustainability. Very few countries are focused on the aspect of space sustainability, space security, because at the very start of a national space program, it's all about getting new technologies, demonstrating that they have the capability to go into space.
It's only later that these countries would look into this aspect. We look at space also as a political and diplomatic tool, whether it's getting the support of the citizens or getting the support of the region.
Finally, most emerging space nations focus on developing their own space agency, but very few focus on developing their own space policy, as well. I think this is a gap that we should be addressing.
When you look at the space sustainability, ensuring the sustainability of the space environment, both emerging and established space nations have their role. For emerging space nations, we need to assess independently what do we need, so that we won't be contributing to more satellites that will eventually become debris, and focus more on what is the national needs.
We need to commit and become responsible players in the international space community. Of course, we have to build our capacity building and capability development. We need to cooperate with responsible space actors, and we need to be more vocal, and active, and dynamic.
In forums like this, as I said earlier, I think I'm one of the very few who is coming from emerging space nations. We need to be more vocal about our own concerns.
On the other hand, established space nations have their own role, as well. They have their own responsibility. They need to serve as role models. For us, for emerging space nations, what we see what other countries are doing has a big impact on how we are going to act as well in space.
Sharing technical and legal best practices, this is I think where the biggest boost or biggest cooperation can happen. Sharing what has been done correctly, what worked, what did not work, is a very big learning value for us.
Cooperating with responsible space partners, making sure that whoever partners with an established space nation should be a responsible space actor. Encouraging development and innovation, this includes not putting a cap on whether a country can launch a cube satellite or a microsatellite, as well.
Taking on the aspect that at some point or at the beginning, it's more like a teacher/student relationship between an established and an emerging space nation, but over time, it would evolve to become more like colleagues.
I'll take an example for the Philippines. As I said, we're one of the upcoming emerging space nations. This is something that we have been working on for the past six years or so. We've launched a couple of microsatellites and a CubeSat.
We've worked on creating our own space agency, and we've even hosted some international space agency forums in spite of not having a space agency back in 2016.
When you look at where we stand, we are one of the few countries in the world that right from the very beginning, we were concerned not just with the creation of a space agency, but at the same time, we created also a space policy. This is something that is very unique among emerging space nations.
We looked at six key development areas on why we are doing this. It's shown here. One of the six key development areas is international cooperation, because we understand the value of why we need to cooperate with other countries, why we need to become responsible players in the international space community.
As I said earlier, we are on the verge of creating our own space program, our own space agency. It's just waiting now for the signature of the president.
I had the unfortunate task of convincing our senators and congressmen, if you think that convincing senators and congressmen in the US to support a space program, it's 10 times much more difficult when you're coming from an emerging space country.
It's always a case of why do we need to do space when we have other problems or other issues that we need to be more concerned with. That has been my unfortunate work for the past three years. Good thing that everything bore fruit and now we're at this stage.
In summary, I would like to say that the responsibility of ensuring the sustainability of the space environment rests both on emerging nations and established space nations. It is only with cooperation that this can happen.

It's only through proper dialogue, through exchanges between these nations, especially with emerging space countries, to be more vocal about their concerns and what they need to do. At the same time, they also need to be responsible space actors in the international space community.
With that, I'll end my talk. Thank you very much.
[applause]
Krystal: Let it never be said that at Secure World, we are afraid to have interactions with presenters who tell us when we're wrong. Thank you for that, because I couldn't agree with you more. We believe absolutely that solutions for space sustainability come through broad international cooperation with all of the actors.
We're actually hoping to do a series of regional workshops in some of these very topics, and certainly one of my biggest goals for future iterations of this conference will be exactly what you said.
Thank you for all of your thoughts. I think that really lays out some of the perspectives that we need to keep in mind for the rest of the event.
Our next speaker is Carissa Christensen, the CEO of Bryce Space and Technology. She's going to be giving us an overview of the rise and promise of commercial space. Carissa?
[applause]
Carissa Christensen: Thank you, Krystal. Good morning, everyone. It's a pleasure to be here. I'm going to talk about commercial space and how it fits into this broad topic of sustainability. In keeping with my frequent conversations with investors, I'm going to take complex nuanced policy issues and present them very simply. I hope this audience will forgive me.
Nations lead the space age. That shaped our experience for many of us, and it shaped our cultural perspective of space. However, today, companies dominate the space economy. What do I mean by that? This is a picture of the space economy. It's not a pure value chain analysis, that's showing the key components of the space economy. We don't have to worry about the detail, but let me just give you a quick tour of what's in here. It's very interesting. If you look at the total space economy, the pieces that I've highlighted here add up to about 360 billion dollars. That brown segment, less than a quarter represents government expenditure globally.
I think that that's a really important framing note when we think about space capabilities and space activities, to remember that governments are not driving all aspects of space activity.
Two notes on that government expenditure. The US accounts for more than half of it, and more than half of that expenditure by the US is for military and intelligence purposes.
Looking more broadly at the rest of that pie, that is commercial space revenues. Those revenues range from launch and manufacturing. Those are those very small segments there, less than 10 percent.
This is public, and I'm happy to share it. The majority of the space economy is revenue from satellite services. There are two huge markets that dominate the space economy, television, particularly direct to home television. Pretty much any television program that you watch, whether it comes to you via a satellite on your home, or whether it comes to you via a broadcaster or a cable provider, has traveled over satellite, the other massive mark -- and that developed about two decades ago, very rapidly -- is products and services that use GPS capabilities or GNSS capabilities.
That's developed rapidly over the last decade. That's particularly interesting. It is a massive, global growing, ubiquitous commercial market, that is based on government-owned, and in the US case, militarily operated satellites.
That's a very interesting hybrid market. These numbers do not include all of the downstream applications that flow from that. This reflects the GPS chipset in my phone, but not the revenues from Pokémon Go, which that enables, not that I play.
[laughter]
Carissa: Commercial space is a critical part of the reality of space activities. I talked a little bit about what companies do. They provide communications. There are some functions that commercial activities pretty much exclusively provide. There's really very little government role, for example, television direct, and in the US, direct radio services.

There are activities that are very much a blend, remote sensing, or earth observation activities. There are commercial companies, there are government operated systems built by commercial companies, often operated by commercial companies at government direction.
There are functions that remain largely government, although we're seeing evolution there, for example, human spaceflight, although we're expecting a relatively soon transition to more commercial human spaceflight, and military, and intelligence activities.
While military and intelligence agencies rely on companies and sometimes rely on the commercial products of companies, those functions are largely dominated by government direction
I want to talk a little bit about the trends and the context, and provide some, as I said, highly-simplified views of some complex topics.
This is looking at those satellite markets over the last 10 years. Growth has roughly tracked global economic growth. This has been an industry that has grown, but particularly in the last few years, we have not seen dramatic growth overall, looking at those established commercial markets.
Why are we having a different conversation about sustainability, and particularly about debris, today than we were 5 years ago or 10 years ago, given this relatively slow trend?
There's a new phenomenon in commercial space that is driving a big piece of that conversation as it pertains to commercial space activities, and that is a transformation in investment in space.
Let me put this into scale. The numbers I'm going to talk about are not these hundred billion dollar television or GNSS-related markets. The numbers I'm talking about are smaller. They're more at the margin of this total space economy, but they're having a significant effect in many ways.
I have a whole deck on why we're seeing this change, but I'm going to give you the very short -- to keep to my 12-minute target version.
Which is that a number of billionaires with experience in venture capital and an interest in space from a legacy point of view, combined with the emergence of an analytics market globally, driven by machine learning and enhanced data analysis providing insight to end users.
Those things came together with the third factor, which is much smaller satellites that can achieve a variety of new purposes. Those things have all come together and have driven a new type of investment space that we've really never seen before historically.
This slide, I think, nicely demonstrates what I mean by smaller satellites. In the background, that really is the most recent Telstar satellite, compared to a Dove satellite that Planet provides, or the SkySat, or the OneWeb satellite that's being proposed by an emergent comm provider.
Why does it matter that we have smaller satellites? Not because these satellites are going to replace our larger satellites wholesale, and not even that they can do tremendously unique things, although they can do some unique things.
What really matters from a commercial standpoint and from the transformation-of-the-industry standpoint is that this enables different investors to play.
If I've got to put together three or four billions dollars to get a business started, there's a certain kind of investor that has that level of capital, and that investor is not a high-risk investor. That investor is looking for a financially engineered return with a relatively limited range of uncertainty.
"Maybe I'll get a 5 percent return, maybe I'll get a 20 percent return, but I'm not going to invest in something that has a 10 percent chance of failure, much less a 75 percent chance of failure.
"However, if I only need..." only, this is the space industry, "If I only need 10 million dollars to get started and 1 hundred or 2 hundred million dollars to get started to build the business" -- these are tiny numbers in the space industry, as well all know.
That puts investment in the realm of venture capital, and we hear a lot about venture capital. We did a study a few years ago. We spent a good deal of time working to come up with a robust operational definition.

Here's what venture capital is. Venture capital is a group of very wealthy people who club together and make investments. They make investments in a certain way, because there is a community of other investors that have demonstrated the success of this approach.
That approach is a focus on technology-driven businesses seeking very high returns, so I put in my investment and I'm not looking for a 20 percent return. I'm looking for a 10 or 100 times return, and to get that, accepting very high failure rates.
The probability of failure of a venture-funded firm, not space, but just generally, three of four venture-funded firms fail. 1 in 10 -- and that's factual, that's data-driven -- anecdotally, 1 in 10 really drives all the returns that a particular investor gets. It's a much different environment.
That means that those investors are willing to put money into ventures that are very uncertain with regard to their markets, with regard to their technology, with regard to their outcomes because they see that potential for very high returns.
This is such an interesting slide. This is investment in startup space companies which we define as companies that have venture or seed angel funding. This excludes companies like Lockheed Martin, but includes companies that have started small and grown big like SpaceX and Blue, or started big and grown bigger.
You can see, since 2015, that massive increase investment in venture capital investment. This is in a report in our website that's not behind a paywall. You're welcome to download it. It's rare that you see that kind of state change, and so that is really what is shaping the industry.
Krystal: Is that the United States?
Carissa: Globally, but the US dominates both in terms of number of investors -- it's actually about half the US and half not the US -- total investment, majority US, driven by a few very wealthy individuals and companies that are receiving investment, and that's largely the US, but we're seeing lots of activity in Asia and Europe.
Here's my last slide. I've heard this morning these marvelously nuanced and thoughtful discussions of the factors that are shaping views of sustainability and have been in space over the last decade, but I'm going to, from a commercial standpoint, boil this down to a very tight thesis.
Why is there a conversation going on now, and how does it relate to commercial space? There are proposed new systems using these much smaller satellites, and those systems have hundreds or even thousands of satellites in low earth orbit. The worry is that those satellites, those systems could create so much debris that the environment becomes inoperable.
The reasons for that, those satellites are smaller, so they're less capable in some cases, so may not be able to safe themselves. There are so many of them. They may have an intentional lower level of reliability, and this is an interesting point.
These constellations have been sold...Part of their strategy is reliability at the constellation level, but accepting lower reliability at the satellite level.
That results in a less expensive satellite because you don't need the testing and the exquisite engineering to achieve reliability of that satellite.
That also creates a debris risk and concern about compliance with regulations. Are these lower costs systems and these new actors going to play appropriately?
The reality is, those risks exist, but they're not perhaps as bad as you might think. A quick chart here, those are proposed satellites. The ones that actually have any money are much smaller proportion than the list proposed. [laughs]
Often, you see projections of future launch rates that reflect all those proposed satellites, and there is absolutely a calibration process that's necessary. Of course there are a wide range of actors seeking solutions and having discussions around sustainability and debris mitigation and norms.
I do hope we have questions because I think there's a very interesting conversation about norms in the commercial world to be had, and I very much appreciate the opportunity to speak.
[applause]

Krystal: Thank you, Carissa. You can always count on Carissa to tell it like it is. If there's anyone more fact-driven in the industry, I haven't met them yet. It's actually a good reminder, I have it on my notes, we are taking questions. We might not have a ton of time, so it is a bit time permitting for this particular group.
A reminder that you can go to slido.com and you can enter the code SWF19 if you would like to ask a question to our speakers during this particular session as well as any of our others.
We've talked about commercial space. Now, let's talk about military space. Our next speaker is Jana Robinson, who's a director at the Prague Security Studies Institute. She's going to speak to us today about militarization and potential conflict in space.
[applause]
Jana Robinson: Good morning, everyone. Just a small correction, I'm not director of the whole institute. I'm director of the Space Security Program. [laughs] There we go.
First, I'd like to express my sincere thanks to the Secure World Foundation, Peter Martinez, Victoria, Brian, and the whole team that put together this wonderful event. I'm glad to be here and be able to address this distinguished audience.
I was asked to provide a broad overview of the key trends and issues related to space security. As this is a large issue portfolio, I'd like to focus on deliberate threats to space activities.
Fortunately, Holger Krag from ESA ably covered the natural hazard and threats for space operations, which was pretty scary, permitting me to speak to the state actor threats, especially of the hybrid variety and how they relate to space security and sustainability.
I'll also introduce the economic and financial dimensions of space security, a rather new subject that we believe will become quite prominent in the fairly near term, especially as allied private sector space companies begin to seek global markets for their equipment and services in earnest.
Finally, I'll make some concluding observations with regard to striking a balance between the benefits of enhanced cooperation and the security imperatives in space.
I think it's fair to say that the global counterspace dynamic, that is, capabilities that could disrupt, deny, degrade or destroy space systems, is primarily driven by the terrestrial rivalries between the United States, China, and Russia.
Several other countries observing this dynamic also strive to equip themselves with improved space capabilities to support their national security. Experts and government officials increasingly emphasize the need for a comprehensive strategy to manage an ever more contested space domain.
The ability of nations to leverage space for defensive as well as offensive purposes is fast improving. Given the rapid pace of these developments, the last decade has witnessed the growing stature of the space situational awareness as an indispensable component of space security.
Space provides support to terrestrial military operations, information, and command and control of forces. Today's geopolitical tensions create the potential for miscalculation or conflict impacting the space domain. Destructive antisatellite capabilities such as ground-based missiles or directed energy weapons feature prominently as a concern due to their offensive nature.
Not all threats originate in space, and vulnerabilities of satellites often stem from their ground systems or communication links. The counterspace activities of China and Russia are being scrutinized as never before, including antisatellite weapon development and testing, as well as reversible measures represented by various forms of interference.
The January 2019 Defense Intelligence Agency and the US Air Force National Air and Space Intelligence Center reports, as well as the annual reports of the Center for Strategic and International Studies and the Secure World Foundation recount a number of examples of this counterspace dynamic.
Recently, a NATO official stated that the alliance countries were recognizing that their price dominance in space also creates vulnerabilities, "The Russians understand it. The Chinese understand it. Space gives us a huge advantage for the alliance," he said.

There is a worrying gray zone spectrum of threats that are associated with deliberate state actions, for example, aimed at probing gaps in preparedness and readiness to protect allied space infrastructure.
Space hybrid operations, that is, intentional, often harmful space actions specifically designed to exploit the links to other domains and conducted just below the threshold of requiring meaningful military or political retaliatory responses are not a new phenomenon, but now pose risks of disruption for civilian and commercial actors, not just allied militaries.
There are no accepted deterrence regimes currently in place to address gray zone hostile activities. In our PSSI's July 2018 report, we offered a list of more well-understood threats such as jamming, spoofing, cyberattacks, rendezvous and proximity operations, and directed energy operations.
We also introduced for the first time the issue of economic and financial space hybrid operations. Counterspace activities in the cyber domain represent a prime example of how to secure an asymmetric advantage without paying a serious price.
The disruption of services that space assets provide would likely have immediate and far-reaching and potentially devastating economic, social and geostrategic consequences. Economic and financial operations are probably the least understood area of hybrid operations.
The space policy community, including private sector space-related companies, has not adequately addressed these more subtle and sophisticated hybrid warfare measures, especially with regard to the steady loss of dozens of countries and markets worldwide due to the predatory space partnering arrangements of China and Russia in the economic and financial domain.
In the course of our research, we tracked and visually mapped all Chinese and Russian space transactions globally over the past six years. We observed that recipient countries often enter into unequal and unsustainable space partnerships through agreeing to vertically integrated control of their space sectors.
We also believe that by collecting an impressive number of international space partnerships, Beijing and Moscow can garner greater influence in multilateral space fora for the shaping of space behavioral norms and standards.
The allied space-related engagement globally needs to be upgraded, we believe, and insist on adherence to accepted market principles, including disclosure, transparency, proper risk management, good governance, and the rule of law, to help mitigate these material risks to the sovereignty of recipient countries seeking to benefit from the seemingly largess of China and Russia.
We also need to develop a democratic model of robust partnerships in a manner that both preserves the space sector independence of the recipient countries and is affordable.
Greater awareness of the multitude of threats relevant to the space domain, including those listed on the slide, is urgently required. We need to better understand deterrence in this new environment especially given the lack of space-related precedence.
Effective mechanism of incident reporting between public and private actors will advance the development of preventive measures as well as crisis management for a number of these threats such as cyberattacks.
Lastly, further capacity building should include a sustainable, democratic model for space partnerships that avoids inordinate dependencies on the part of the recipient countries.
To conclude, a space technology is and inherently dual use. It is especially challenging to configure an overarching architecture for the governance of space that would cover both commercial and military space activities.
Absent active diplomacy that enhances the transparency of space activities and promotes confidence among space actors, incidents and even conflicts involving the space domain is likely and possibly in the near term.
Norms and TCBMs can guide and strengthen UN treaties and principles on outer space, as well as support and even more robust consensus reflecting the changed space environment. In short, there is an urgent need for visionary political leadership that can manage increasingly complex traffic in space and counter irresponsible activities there.
I'll stop here and look forward to the discussion. Thank you.
[applause]

Krystal: Thank you so much for highlighting new ways of thinking about security and stability, particularly given the changing geopolitical landscape.
Our next speaker is one I'm particularly excited to introduce. Her name is Anne Hale Miglarese. She's from the Radiant Earth Foundation, and she will be talking to us about the role of space for benefit on Earth.
I think this is a particularly important topic. We're all here. We care about this topic, but it's helpful to really think about why we care about this topic. What actually happens in the world on a daily basis for everyone if we don't actually make progress on space sustainability? Anne?
[applause]
Anne Hale Miglarese: Thank you, Krystal. Good morning, it's great to be here. I've got happier news than that. [laughs] To tell you a little bit about the Radiant Earth Foundation, we are a relatively young organization, just at three years old.
Because this market is changing so quickly, like Carissa mentioned, we pivoted just a week ago and changed our mission because what we found was we had put ourself right in the middle of just some tremendous commercial competition.
We're a non-profit. We're funded by the Bill & Melinda Gates Foundation, the Omidyar Network, the McGovern Foundation, the Schmidt Futures fund. Certainly, that's not where we want to be.
There is so much to be done with the value of Earth observations that we try to wicker down our mission to focus, going forward, on building the tools and the resources necessary, the open resources and the open data for machine learning on Earth observation.
Let's talk about the remote sensing and Earth observation market. I've been in this business for 34 years, and I have never been so positive of what we can achieve. It used to be, I remember when I was in graduate school, we had Landsat. That was it. People wondered, what's the value of Landsat?
I remember I grew up in a pretty political family and knew Senator Hollings pretty well. He was certainly an advocate for the program, but he was like, "Anne-Marie, I just don't know about this."
[laughter]
Anne: Look at where we are today. Look at those slides that Carissa presented. I developed this slide a year ago. I think it was November of last year, and I have quit trying to update the number of Earth observation satellites launched on a regular basis, and I just put, "Greater than 600."
It's not just the US. Certainly, Planet has gone a long way to driving that number up, but what I see in traveling the globe, and particularly, I spend a lot of my time in the global south, is that it is becoming a global industry, one that I would argue, from an Earth observation standpoint, the US no longer leads.
You intersect that with the mission that we have in the global south with the drone imagery that we're starting to see, and the data that's coming off of drones, and the innovation that's occurring in Africa.
Because there are very few rules about where a drone can be flown and a tremendous amount of necessity, and people that are local that are solving their own problems and building their own drones, and the motorcycle mechanics that are fixing those drones. [laughs]
The explosion of data that we have now made possible this big data, and, as all of you know, satellite data isn't just big data, it's fat. It's obese, and it would not be possible to do with this data what we can now without the emergence of cloud computing.
It's just amazing. How that has driven down cost and increased the speed of access, intersect that with the innovations that we're seeing in machine learning, and the work that we're starting to do with integrating that with the Internet of Things, blockchain, and we're very close, I would argue, in five to seven years, of getting a digital twin of the Earth on a daily basis.
What does that mean? The innovation, the new solutions are just amazing, and that's why I've never been so positive about the value of Earth observations to help us solve some of the world's most difficult problems.
Part of my job is to track the remote sensing market, and I focus our communications on individuals in the global development community, organizations like Catholic Relief Services, organizations like CARE, organizations like Doctors Without Borders, because they too now have remote sensing professionals, but they're front line people.

They are the last mile to delivering vaccine, to delivering bed nets, to dealing with a whole host of problems, and so I started publishing once a quarter on some of the innovation that we see.
I spent a lot of time looking at the government satellites for Earth observation as well, but look at how quickly these commercial companies have come. These are the visible EO satellites.
I would also say we're...not moving forward. There we go. The commercial radar satellites that we're seeing, that's particularly important in the Global South, where we often have the visible data is obscured by clouds. We're seeing a real integration, a lot of creativity in integrating radar satellites.
Finally, I'll mention the commercial weather satellites. I want to hand it to SpaceX for the launch last night on the Falcon Heavy of the long-awaited orbit of COSMIC-2, a US and Taiwan program for GPS radio occultation to improve weather forecast.
With our focus now on machine learning as many of you probably know, what we lack are training data sets. On the left, you'll see this image of agriculture. Almost all of that is in the Global South, except for the bottom right-hand quadrant.
Agriculture looks different in different regions all across the globe. Most in the Global South, many of those are small leaseholder farms. They're multi-cropped. There are four crops within two hectares.
Using machine learning to do predictive analytics on crop type, as well as the amount of the harvest is very, very difficult, so the lack of geodiversity, scarcity of data.
We still have a lot of interoperability problems. What we're seeing is a bias or incorrect results and the inability to capture the wide range of possible outcomes. That's where our work is focused.
I do want in just a few minutes to share with you some of the most creative applications I've seen as of late. This one actually is in the US, but it's just mindboggling to me. This is done by Oak Ridge National Labs and Dr. Budhu Budhendra.
Budhu has the great pleasure of having the world's fastest computer, Titan. I'm sure the Chinese may overtake that the next month or two. That seems to be a rolling debate about whose computer is fastest.
Budhu has long been working on machine learning for buildings. He started his work in Africa, working for the Gates Foundation.
I'll show you some of that in a minute. Budhu was able to map, and Oak Ridge National Labs, every building in South Carolina greater than 10 meters in less than a day with machine learning.
There are a whole series of slides from his presentation on this. He was actually asked by FEMA to do this, and he did it for the entire Southeast in less than a month, because it was hurricane season. This project would have taken a decade and $100 million just five years ago, probably, without machine learning, the pace of that innovation.
Budhu developed this technique, but now it's being transported to the continent of sub-Saharan Africa. Why has the Bill and Melinda Gates Foundation invested in this? Because census data is exceptionally poor in Africa and in the developing world, to know how to fight malaria and polio, you have to know where people live, and you have to know where people move.
Digital Globe is now a major provider of this type of information. These are the buildings in Mozambique. This is the first iteration of the product that the Gates Foundation uses, then they turn over to a research scientist in London, and he intersects all of these buildings with call data records, and then they estimate the population. This work goes directly into their polio program and how they distribute vaccine and the supply chain for the polio vaccine.
One project that my team did is for the Bill and Melinda Gates Foundation and the Sustainable Development Goals, of clean water. The Gates Foundation pays to operate wastewater treatment facilities in Senegal. They pay commercial operators.
There are no independent checks on the volume of waste that is coming through these facilities and being treated. They're just getting an Excel spreadsheet bill once a month and they were [inaudible 87:01] checks. That can get pretty expensive over time.

They asked us to set up a machine learning on-Earth observation technique to monitor these facilities in Senegal. We originally started with the Sentinel-2A and 2B programs. The results were OK. They weren't great. Then we added Sentinel-1 -- that image you saw earlier was Sentinel-1 that was hit by debris -- and our results went up dramatically.
It's not the sexiest example you're ever going to see, but it's important. Clean water is important.
With that, I'll close by talking about some old problems that have persisted and new problems that are emerging that we're seeing. This is primarily in the developing world, and that is connectivity.
There are three billion people most of where we work don't have Internet. Oftentimes, we try to work through universities, and the Internet is still very, very spotty. We need those billionaires that Carissa referenced to get busy with all their billions and actually get us some Internet from space.
Collaboration and data sharing, it's still a problem. It is a very big problem in developing nations that are worried about holding on to their data, capacity development and growing the technical skills, and supporting the growth of that in those countries, and funding, clearly.
The new problems that have emerged with machine learning on Earth observation, privacy and ethics, I think our community has generally stuck our heads in the sand and said if you can't see an individual's face, there aren't any privacy issues. That's just not true, particularly as we intersect the imagery with other machine learning data types.
Training data and technology standards, and staying abreast of this very rapidly moving market.
With that, thank you.
[applause]
Krystal: Thank you so much, Anne. I just think it's important that we remember that one of the reasons that we want to make progress in space sustainability is not just to support business plans around the world, but to save lives and to influence lives.
I think that was a really good overview of some of some of the amazing technologies that are being applied all over the world. Thank you, again.
Our last speaker is going to be Niklas Hedman from the UNOOSA office. He is going to speak about the past and future of space governance.
While he is coming to the stage, I want to remind everyone that since all of our speakers have generally kept to time, we will have some time for questions, so take a look at Slido. When we're finished, we'll have everyone come back up on stage for a few minutes.
[applause]
Niklas Hedman: Thank you, indeed. It's an honor to be here. One of my functions is to serve as secretary of COPUOS and H-2 subcommittees. I will, of course, center a lot around the work of COPUOS.
Holger started this panel by stating that he was going to erase the negative facts. I can end this panel by talking about the positive future.
[laughter]
Niklas: Of course, this is a challenge. If I could predict correctly the future of space governance, I would probably be among those billionaires, and I'm not, but I will make an attempt.
This picture is not from the COPUOS session that ended last week. It is a few years old. It's David Kendall of Canada who presides over the session, and I am much slimmer in that photograph.
[laughter]
Niklas: COPUOS this year managed something iconic and historical. We adopted the preamble and 21 guidelines on the long-term sustainability of outer space activities.
We also moved ahead on the Space2030 agenda and implementation plan, and we also moved forward in the work we have under a multiyear work plan on governance and method of work. These are three really important key features in the global governance of outer space activities.

If you look at the original COPUOS, in 1959 when this intergovernmental body became a permanent body under the General Assembly, it started, of course, by outlining its mandate. Yes, this is the mandate of COPUOS, those four bullets. As you can see, it's very general and it's rudimentary.
There is a constant debate, whether COPUOS should adopt a more detailed mandate. At the same time, there are views saying, "No, why not? This body has worked constantly over 60 years and delivered."
If you look at the last bullet there, study legal problems which may arise from the exploration of outer space, that is the mandate given by the General Assembly to COPUOS to develop the lead regime of outer space.
If we take a step back and look at the history of COPUOS, we can structure the way COPUOS has worked for 60 years into eras. 1960 to 1980, the era of treaty making, five treaties came out of the work of the legal subcommittee and eventually COPUOS.
1980 to more or less 2000, we had the principles era, where COPUOS managed to develop five sets of principles that have a more or less higher standing than resolutions guidelines and frameworks.
Between 2000 and 2020, also an era of 20 years, we have the creativeness of developing resolutions that actually also go into guiding member states in applying the treaty regime. Some of those resolutions, in particular the registration practice resolution, also provides some common interpretation of the registration regime.
Then the forthcoming era, 2020 to 2030 -- 10 years only -- that is what we are now targeting the 2030 agenda for sustainable development.
Currently, COPUOS is vibrating. It has never been as active as it is today as an intergovernmental body. This is just a snapshot of more or less the broadness of agenda items being dealt with in the main committee and its two subcommittees.
What's particularly interesting here is the box on space safety, security, and TCBMs. This goes back to 2030, and you know it very well, the GGE report on TCBMs in outer space activities, which opened up for this intergovernmental body, which is only concerned with international cooperation in the peaceful uses of outer space, meaning civilian space cooperation and activities.
With that report, we also entered into what we now label as the broader perspective of space security, meaning that you cannot separate and isolate safety, security, sustainability. That meant a lot for this intergovernmental body.
It also opened up for our office, the Office of Outer Space Affairs to work more constructively with the Office for Disarmament of OS. That has meant a lot also for the global community.
It's interesting to note how active COPUOS is in a broad variety of topics and items that concern all levels of space activities. Considering that COPUOS today has 92 states members, and in fact last week, COPUOS recommended Singapore, Rwanda, and Dominican Republic to become three new states members reaching to 95 next year.
If you look at this list of states, I have grouped them according to Africa, Asia-Pacific, Eastern Europe, Latin America and Caribbean, Western, and other states. You will see that it comprises a diversity of the global community.
You have there space users and you have spacefaring nations. All the major spacefaring nations are members of this intergovernmental body. You can also see another interesting point here that, among the groups, it's fairly balanced. You have more or less an equal distribution of membership from all parts of the world.
This is also something important to take into account of the broadness and of the mission of COPUOS to reach out to all countries, whether they are using space only or whether they are actually going into space.
This also creates challenges in the work, how to further develop governance and make instruments that work if we are so many countries with so diverse backgrounds. In that sense, COPUOS has developed a very flexible system of working with various mechanisms and tools.
Working groups, expert groups, action teams, and now we even have something we have labeled as scheduled informal consultations.
One of the most interesting features here is the creation of the action teams under the voluntary leadership of individual member states in the implementation of the recommendations of UNISPACE III, the global conference held in 1999.

One other interesting point here is also the long-term sustainability of outer space activities, which started with the working group under Peter Martinez's leadership, and immediately set about to create four expert groups, expert group meaning a loose structure, less formal, with more expertise in their working plans.
That helped tailoring what we have seen now, what we can see now with the result of the long-term sustainability guidelines. Keep that in mind that COPUOS is working with quite flexible mechanisms in order to uphold a governance structure throughout its work.
COPUOS needs help. Here we have the Office for Outer Space Affairs. I have put down three key features of the office.
The office's role as a capacity builder, the office's role as a convener, not only as a secretariat of COPUOS, but also to provide room and place for stakeholders, both from the governmental side, nongovernmental organizations, and private sector, and also the role we have as a gateway.
The Office for Outer Space Affairs is the only dedicated UN entity that has a broad mandate across science, technology, law, and policy of space affairs in the UN system.
2015, we know, the creation of the 2030 Agenda for Sustainable Development, where the world community merged the global development agenda with the sustainability of environment agenda. Those two then became the concept of sustainable development, reaching also beyond environmental sustainability.
17 Sustainable Development Goals focused on areas of people, prosperity, peace, partnership, and planet. It is the broadest agenda so far in the world community.
2015, that is more or less the time when we started the preparations for the 50th anniversary of the 1st United Nations Conference on the Exploration and Peaceful Uses of Outer Space, labeled UNISPACE+50.
With this in mind, COPUOS, in 2015, created a set of five crosscutting areas where COPUOS members together with the secretariat assessed how member states of this intergovernmental body, its secretariat, and other stakeholders, both intergovernmental and nongovernmental, have for the past 50 years...
I would actually say past 60 years, because it's not only related to the 1968. No, it goes back to the foundation of COPUOS. How we have expanded and developed under those five core areas, governance, capacity building, resiliency, interoperability, and space for sustainable development.
Out of that assessment process came the decision to create seven thematic priorities. I just listed them here. I'm not going to go through all of them. I wanted to list them here so you can see the seven thematic priorities, how broad this platform has become.
The two important interesting points there is that thematic priority three, enhanced information exchange on space objects and events, which deals with what we are also discussing within the long-term sustainability framework and elsewhere on TCBMs, as well.
Risk reduction measures, that it's still to be decided, obviously because we needed first to conclude the long-term sustainability guidelines.
The next point I want to raise is TP2, thematic priority two, where we are now concentrating our efforts in developing a guidance document for decision and policymakers at the national level, which means that COPUOS is becoming a capacity builder, too.
This guidance document is summarizing, putting into context what we have done so far over the 60 years in the normative framework. I love this. I simply cannot stop you seeing this.
This is a shot we created when we started UNISPACE+50. It's so fantastic. Look at it. How can five become seven, and then four? It's simple. The five crosscutting areas led to the seven thematic priorities. The fourth pillar served to explain to communities outside of the space community, what it is at stake here.
Space economy, space society, apace accessibility, space diplomacy. We have heard those terms being used in other presentations so far.
Now, member states of COPUOS are now driving a process towards what we labeled as Space 2030 Agenda. As you can see, obviously, there is a close connection to the 2030 Agenda for Sustainable Development. I have put it down there, people, planet, prosperity, peace, and partnership again.

My final conclusion, and allow me to just offer some projections again. I'm not a billionaire. What is needed here, I believe, is first of all, really to focus on capacity building. Capacity building and awareness increase again. There were some presenters before me, that really pushed how important it is to do concentrated focused and professional capacity building.
We need an increased dialogue with private sector actors. Everyone knows that, but it's very difficult in an intergovernmental context in the UN system to really do it. This is needed. We heard a presentation earlier saying how important and dominant the private sector is today, and will be in the future.
We need now to look into an organized reporting on the implementation of the long term sustainability guidelines, and we have already set in motion a first step in that regard. We need to further develop those guidelines or other areas within the long-term sustainability of outer-space activities.
Organized reporting, it's important to do this right, not only submit reports but to do it in an organized fashion.
Going back to this thematic priority three, you remember, we need structured information exchange on space objects and announce risk reduction measures. When this is developing, we could see the fabrics of a future space traffic management regime.
Remember my initial comment, the 20-year eras, 20 years of treaty making, 20 years of principles, 20 years of resolution, guidelines, frameworks, and now 10 years of long term sustainability. In 10 years' time, we will have a space traffic management regime, and I will become a billionaire. Thank you.
[laughter]
[applause]
Krystal: If all of my speakers could come back up on stage. Thank you, Niklas. Thank you. There's a lot of acronyms. The Committee on the Peaceful Uses of Outer Space doesn't necessarily trip off of everyone's tongue. I think it's important that we understand the foundation for space governance that's in place, and what it's evolving into.
A reminder for everyone, that we are using Slido. I will be asking a few questions based on what I see coming in. You can also upvote questions if you see one that you find particularly interesting, and we will take that into account. I'm going to start with Carissa.
What are VCs saying about the greater space operation risks that stem from space debris? Is that something that you think is built into their calculus to invest?
Carissa: That's an excellent question. Mostly what they say is, "which of the companies seeking to address space debris do we think might make money?"
[laughter]
Carissa: Quite seriously, space debris is certainly perceived as a business opportunity. It's a challenging business opportunity because of any pollution cleanup problem, it has the difficulties of who is your actual customer, with regard to satellite systems, low Earth orbit satellite systems, and their operations, and launch, which is where the majority of VC funding has gone into.
Generally speaking, those companies fall more on the side of cause than effect. That is, those are companies that are creating concerns about potential debris as opposed to being concerned about debris as a barrier.
The narrative that I think is most common is the following. The concern about LEO smallsat systems creating new debris and reducing the operability of the space environment are not reflective of the fact that those businesses go out of business if they foul the environment they operate within.
Generally speaking, I think that community, both the satellite operators and the investors, tend to view the incentives for self-regulation as so strong that the consequences are not a major factor in their consideration about future operations.
Krystal: Thank you. I'm going to move to Anne, next. I think I know the answer to this question, but I'd like to hear your take on it. Do people who rely on EO data understand the significance of the threat to the space environment on their potential work?
Anne: No.
[laughter]

Anne: I think in all of the dialogues that I've been a part of in the remote sensing industry, there seems to be a real disconnect between the manufacturers and the launch companies and the end users. As Krystal said earlier, trying to bring a crosscutting community together, but I have never once in a conference in remote sensing ever heard anybody talk of that threat.

Krystal: I'm going to follow-up on that because we're going to talk about this tomorrow, as well. How can we change that? What is the narrative that we need to, because when we talk to folks who need to make some of these decisions, they're not all space people. We need to understand the importance of many of those folks. How do we change that narrative?

Anne: I spend most of my time with end users, and remote sensing scientists, and geospatial people, but having convenings, being in the forums where they attend.

They're not going to attend generally an organization like this. In fact, I have to leave this afternoon to go three blocks away where there are 200 remote sensing scientists from all over the world working on famine early warning systems and food security.

They're talking about Sentinel-2, and they're talking about drones, and they're talking about land sat, and they're talking about data cubes, but they're not talking about a secure space environment.

Krystal: Thank you. Shifting focus a little bit, we have a question saying, "Responding to the emerging nations' presentation and the continued dominance of traditional spacefaring nations, isn't the key issue the predictability of the regulatory setting?"

I'll start with Rogel, but I'd be interested if anyone else has thoughts on this as well.

Rogel: I think this is where we see that space can be used as a diplomatic tool. While in some cases, yes, space can be political, and the way that the guidelines are being set are dominated by spacefaring nation, this doesn't preclude that emerging space nations should be also vocal about their concerns.

It's only with these repeated raising concerns and issues that is important for emerging space nation that we can shift the discussion to have a more balanced perspective when we are setting our guidelines.

While, yes, that it has been the norm for the past decades, I think this is a turning point, as well. We can see this as a turning point that once emerging space nations become more active, we can see a more balanced perspective in terms of setting the guidelines.

Krystal: Anyone else? Niklas?

Niklas: Yeah, I would like also to echo what you say. We see that frequently. There is no way that we can create something global if we don't include all states. Considering that many emerging space nations, least developed countries among them, today are deploying small sats, CubeSats, they become spacefaring in one way or the other.

It's important then to reach out to those governments and really be clear that the government needs to uphold responsibility, potential liability, registration, and control activities under their jurisdiction.

Krystal: We have a question for Carissa, but I actually think this is another one that I'm very interested in hearing more opinions on. "What role do you see the commercial space sector in playing in establishing norms for responsible use of space?"

Carissa: Thank you so much for that question.

[laughter]

Krystal: Just solve all of our problems right now and save us the time, rest of the day.

Carissa: This is a very persistent conversation. This comes up particularly in military and intelligence environments. When we talk about norms, I think the first thing to clarify is, there are two very distinct meanings to norms, and I know this was discussed yesterday a little bit.

Just to highlight that, there are norms that are standards and rules that are promulgated by an organization that has some authority or has been given authority, that define the appropriate ways for members of a community to behave. Often, when we're talking about norms, that's the definition we're using.

There's another very important definition of norms, which is, in a community, in a system, norms organically develop the ways in which people and organizations behave. Those norms are important. They have power. They

help shape expectations. They shape the likelihood that those promulgated norms will be accepted or enforceable.
There is a very active commercial space community. It's been active for decades, and that community has developed norms.
There are expectations with regard to, "I'm a commercial satellite operator. If your satellite is going to disrupt my operations, or come closer to me than I'm used to..." "If I'm conducting certain kinds of tests, I notify you, I coordinate, I share that information."
There are expectations. Those norms, there's a huge array of civil space norms in order to protect our astronauts and our on-orbit assets.
Those norms are often viewed as not relevant or not achieving the goals of the norms that we're seeking, and certainly in military intelligence conversations. That is because they don't translate into the reason norms are so important in those conversations is rules of engagement.
What are the behaviors that are so inappropriate? You spoke as eloquently about behaviors underneath the level of what requires a military response. Terrestrially, we know the kinds of behaviors that allow and require a military response.
What is a hostile act in space? What's hostile intent, particularly if you're talking about systems and people? The problem is, we have norms, but they're not memorialized, edge cases are not documented. They're not quantified, and so they don't slot into a discussion of rules of engagement in an effective way.
That said, those norms are real, and they exist, and they should form the foundation of this conversation. Otherwise, you've exchanged one problem, memorializing norms, for two problems, memorializing norms and then overcoming the organic norms to institute the new memorialized norms.
Krystal: Holger, "What are your thoughts from ESA's perspective on this question, the role of commercial sector in establishing norms?"
Holger: It is the commercials that are the experts on the particularities of the system. Definitely, letting others setting up norms in ignorance on the technical constraints large constellation brings would not be the right thing. On the other hand, we do have the tragedy of the space debris problem is that it has a long delay from the time where we are behaving wrongly to the effect that it actually takes. We are talking about decades, so that time span is much longer than the normal business case we are expecting.
What we are suffering now of are the mistakes of the '60s. [laughs] The mistakes we are probably going to do now will probably not affect the commercial actors of today. They will affect the commercial actors of several decades ahead.
That means that a very strong rule must be associated to actually those that have an interest in covering the interests of the future generations, to my mind, are primarily the states and state actors that represent everybody.
Krystal: Thank you. An interesting question for anyone who's willing to take it, besides Jana, "Are the others concerned about the rising tensions for conflict in space?"
[pause]
[laughter]
Carissa: I will speak to that, and I will say I am more concerned about rising terrestrial tensions than I am about specific space-related tensions.
[pause]
Krystal: All right.
[laughter]
Krystal: I could make someone speak, but I will go ahead and move on to other questions. This is an interesting one. For Rogel, or any of the others as well, "Do you believe policy should come before the program, or should it be created simultaneously?"
Rogel: I'll take that question. I think this is an issue that we were contending in the Philippines back in 2013, whether we should create the space agency first or the policy first. The way we approached that problem is, we

looked at how our own country's governance or government system works and tried to see which one would work well.
In some cases, it's a chicken and egg problem. If you have a policy with no space agency, it's a piece of paper. If you have an agency with no policy, that has been done a lot of times, but the way we did it is, we established both the policy and the agency at the same time. That created a much strong push for having the space program, especially for an emerging nation.
In summary, it would depend on how each country's way of governance works. If it can work with an agency without a policy, that can happen, but it's much better if you have both the policy and agency at the same time.
Krystal: Any other thoughts on that? Here's an interesting one for Niklas. "How can small space actors better balance the time and cost of requirements for participating in the COPUOS dialogue while still running their organizations or countries?" It's a long process, as you eloquently stated.
Niklas: Yeah, I know, and this is of course a constant issue, considering that we have five and a half weeks meetings every year. We have now set in motion, as I indicated in my presentation, a multiyear work plan where we're looking into COPUOS's internal governance and method of work.
As part of that, we will take measures in making information more available. They might be in the future of the webcasting of sessions, which means that delegations don't necessarily need to be the fulltime in our sessions.
At the same time, it's important to note that COPUOS is not only the formal process of its agenda items. It is also an important networking platform.
We see delegations coming, and particularly in the Scientific and Technical Subcommittee, there's a lot of representatives from space agencies, from research community, and this is the venue to meet, so it's also a priority, of course, in that sense.
Rogel: Can I add a little bit to that?
Krystal: Absolutely.
Rogel: Actually, that's also an issue that we have. This is where the space agency should be working with their own foreign affairs ministries, with their embassies.
The UNOOSA is based in Vienna. Most countries would have a permanent mission. In the case of the Philippines, it's actually not representatives. We don't send delegates to COPUOS. It's actually the permanent mission in Vienna that represents the Philippines in COPUOS.
I think a more active exchange of information between the embassies or the permanent missions in Vienna and with their own countries, that can also be a key to having increased participation, especially for emerging space actions.
Krystal: Our next question for Jana. "Could you speak a little bit about some of your ideas about specific ways that we can increase dialogue with Russia and China, for instance?"
Jana: I think there are a number of international fora, and COPUOS is one of them, where there is an extensive dialogue. I believe that there are other venues, bilateral and others, where there exists a dialogue. I think one of the problematic aspects is how do you talk about the difficult issues.
One of the things that was not mentioned during Niklas's presentation is that once you get into the more security-related operational issues, those are the most challenging. We should, of course, make it clear that all of us want stability in space.
We just have to understand that, so far, we feel that there are different ideas of how to do that. That way, I believe that we still have to rely on some bilateral exchanges before we move to multilateral fora. Inevitably, there are those efforts, and they should continue.
Krystal: Any other thoughts on that? Not surprising.
[laughter]
Krystal: I have a question for Holger. You started your talk off by saying, "Hey, this is some bad news." What's your assessment? Is the environment getting worse faster? Are we falling behind on taking action, are we at the exactly right point, are we ahead of the game? What do you think?
Holger: In the whole history of spaceflight, we haven't hardly seen a period where the environment got better.

[laughter]
Holger: If you look at statistics, we are in an accelerating phase now. Sorry, what was the [inaudible 123:32] ?
Krystal: Where are we in terms of addressing this? Are we falling behind? Is the problem getting worse faster than we can actually address it? Where do you think we are? How urgent is what we're here to talk about?
Holger: I think we are falling behind. We need to cope with an increasing launch rate. The trends in implementing the countermeasure doesn't catch up with the amount of objects we continue launching. In absolute numbers, we are adding more and more every year. It's about 40 to 50 objects that gets stranded today. That could have been removed easily if we had successfully been implementing the mitigation measures. We failed. It's the absolute number that matters, after all, so 30 percent of 100 satellites gives you 30 objects, but 30 percent of 1,000 satellites gives you disasters. Yes, I have the impression we are falling behind.
Krystal: I have several questions on insurance. I have a feeling that these are mostly going to go to Carissa. I'll start with one of them, but I'm broadly interested in your thoughts on what role insurance might be able to play in the space sustainability question.
One of the specific questions we have is, "How does the insurance sector affect the financial lowering of the risk with regards to space debris for interested investors?" I'd be interested in any broad thoughts you have on this as well.
Carissa: Generally speaking, the dynamic of satellite launch, satellite operations, and insurance, particularly for the very large, expensive commercial satellites in the GEO arc, is extremely well-established. There's a very highly functional system. There was a period in the '90s where there was a huge disconnect and the insurance industry lost a massive amount of money due to a series of losses.
It's reasonably well-calibrated now. There have been a few difficult years. There have been new entrants into insurance. Particularly, hedge funds have been putting money into space insurance, which has changed, a little bit, that environment. There's that established system.
There was recently a very interesting case. You probably read about it. Intelsat had a failure of one of its satellites after just a couple years. That satellite was not insured for on-orbit performance. That was a massive loss because it was a high-throughput satellite that was intended to drive significant revenues.
There is concern that there are other satellites in that series that are vulnerable to the same kind of loss. Intelsat made that decision because satellites fail so infrequently.
The LEO environment is different. You've got constellations. As I mentioned, you have potentially a lower reliability for those satellites. You've got a much less established business case and much more uncertainty about the business prospects of those ventures.
I would expect to see relatively higher insurance rates, and I would expect to see more limited insurance products. If there's anyone from the industry here who wants to chime in about how you're thinking about it, I'm happy to defer.
Debris risk is certainly part of that risk, but from an overall operational standpoint, looking at the full range of lifecycle risks to your business, debris is certainly, at the moment, likely not the primary risk. I would say it would have some marginal impact, but that's not going to be the core of the business discussion.
Krystal: We're going to do two last questions, both of which are for everyone, one of which is more positive than the other. "If the large fraction of VC-backed companies fail, what should be done to ensure their satellites aren't abandoned on orbit?" I.e., not everything's going to work. Some of it is, some of it isn't.
For this particular problem, what do you think? Holger, how about we start with you?
Holger: That's the one on the insurance? I'm probably not the best to answer that.
[laughter]
Holger: We are frequently approached by all the insurance companies. They're using risk models that we are providing. That's definitely a topic that is taken up. We also realize that the company make use of conjunction and collision-avoidance expert services in order to reduce and relax insurance costs. That topic is slowly migrating into the insurance area.
I don't have an overview on our business spreading out further.

Krystal: For the next question, if a large fraction of VC-backed companies fail, what should be done to ensure that we don't have more problems from that particular situation? Carissa?
Carissa: I can offer a historical example. The Iridium satellite system was deployed and went bankrupt. What happened there was, at the surface, the market acted the way that you would expect it would. That distressed asset was purchased from the investors who lost all their money by a new set of investors who were able to turn that now deeply subsidized business into a success.
The reality behind that surface story is that it took very directed and focused action by some government leadership...I'm not going to name names, Doug Loverro.
[laughter]
Carissa: ...to help engineer that outcome. You create valuable infrastructure. You can't make a business out of it, someone else may be able to because they don't have to service the costs that you incurred in establishing that infrastructure.
The difference between that situation and LEO satellites today, shorter-lived satellites, more complex ground networks, so if you've got a satellite system where the satellite life is two to three years, you may then simply not have time to establish that new business before you'd have to deploy the next generation.
I would say that if, in fact, we want to preserve those assets once they're deployed, that may well take intentional government action to either acquire or facilitate the acquisition of those systems and serve as an anchor customer, which is what made the difference for Iridium.
Krystal: Holger, did you want to take that since we got confused over which question you were responding to? Did you want to respond to this as well?
Holger: I want to respond to the one that I can really answer.
[laughter]
Holger: That would be the one on the top. That is a very good question. My own director asked me exactly the same thing. Our satellites are at risk because of all the small objects that are so numerous. It is so much more likely that your satellite is actually killed by a tiny object, which are so numerous, compared to all the big ones. Why do all the mitigation measures and all the actions, active removal, concentrate on the big ones? That is because the big ones are the source of the small ones. A single fragmentation event or collision, Iridium-Kosmos, generated 100,000 objects of one-centimeter size and larger.
It is the atmosphere that helps to clean out the space environment, and it is the small objects that leave environment first. They are more sensitive to atmospheric drag. The environment helps us, cleaning out the small ones. If you don't tackle the big ones, then we will constantly reproduce the environment of the small ones. That is where we have to put priority.
Krystal: We have about five minutes before our coffee break. I am quickly scrolling through. Of course, we're going to have technical problems.
I want to end on a broad question. Obviously, this panel was meant to set a very broad overview of a lot of the different topics that we want to cover. While there's a lot of synergy here, there's also a lot of differences. Perhaps we could have each person give one closing thought.
What do you think we need to be talking about when it comes to ensuring progress on space sustainability for, say, the next 10 years? What is your closing thought based on what you've heard so far? Niklas, go ahead.
Niklas: I think we should, honestly, all of use, go back to the initial question, the question that delegations COPUOS asked themselves 10 years ago. What do we need to do in the future to secure that we can continuously use our space assets for sustainable development on Earth? That is the key question.
Krystal: Anne, did you have any thoughts?
Anne: I would certainly echo that, and I would say there are a lot of lessons learned about sustainability here on Earth that should inform our approach to space.
Krystal: Carissa?

Carissa: In the context of that broader objective, the specific tactics in the order in which they're undertaken, in an environment of limited resources, making those choices effectively really depends on serious policy analysis and evaluation of real risks, as opposed to perceived risks driven by media or political concerns.
Krystal: Jana?
Jana: From a security perspective, I believe that we cannot hope that we can rely on the status quo that has been established after the end of the Cold War. That paradigms has long changed.
I think we have to recognize it and in our policies, in our strategy, but increasingly also in the outreach in terms of interaction with the industry and commercial actors that do want to engage globally, and they can actually probably feel it as one of the first ones when they go out there into the world.
We have to recognize first of all that we cannot just do it on a government level, and secondly, that we really need a shift, a change. We have heard a lot of discussions on security in all fora or COPUOS conference of disarmament, bilateral meetings, but we seem to witness that the geopolitical situation is not getting any better. What can we do in terms of making sure that this is not the case, including what kind of penalties we can actually think about in terms of when there are irresponsible actors in space? I think we don't really have a lot of options today.
Krystal: Rogel?
Rogel: I think for the emerging space nation perspective, it's more about ensuring that there is constant dialogue between the emerging and the established space nations, there is transparency in these dialogues, and ensuring that there is equality in terms of the exploration and the use of outer space.
Krystal: Last, but not least.
Holger: I think since 2002 when the IDC brought out the guidelines, we know what needs to be done. It appears the most important nations, most spacefaring nations, these things are repeated in the national law, so it is clear what needs to be done.
When I show that only 30 percent do it, it's not only bad intent. It is because there's a lack of technology to do that reliably. I think that's one of the first things we need to do. We need to help them to get more robust, more reliable with actually implementing these things. It's the role of an agency to help the industry getting to this.
The other factor I think we need to be stressing is to control the implementation not only up to the launch, where we do this quite intensively, up to the launch, clearance and license. On paper, all the things are fulfilled.
After that, we need to actually go into the mission while it is operated and to check, like you would do with your car on the road, every two years the health status and continuation of the license for that particular mission.
Krystal: Thank you to all of our Spotlight speakers for your unique and incredibly insightful comments. I think you accomplished what we set you to do, which is set the stage for the rest of the conversations that we want to have today and tomorrow.
[applause]

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