Summit for Space Sustainability

Panel 4: Why Space Sustainability is Crucial for Life on Earth
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Moderator: Krystal Wilson, SWF Director of Space Applications Programs

Panelists:
Carlos Alvarado, Central American Association for Aeronautics and Space
Chris Aubrecht, European Space Agency & World Bank
Ed Parsons, Google
Danielle Wood, MIT

Krystal Wilson: All right, everyone. I'm not sure which story was my favorite. It might be hearing the inside scoop on exactly what it was like to learn about the Iridium-Cosmos crash when it happened. We have a lot packed in this morning. Again, thank you all for being here. Thank you to both of our interviewees and our interviewer. That really gave us a new perspective as to what we heard yesterday.

Now we're going to shift gears a little bit. We're going to move on to a panel, which is actually my area of expertise so I get to be your moderator for the next 45 minutes. Why is space sustainability crucial for life on Earth? We aren't going to do any formal coffee breaks. Just a reminder, logistically, there's coffee on your table. Feel free to come in as you need to, and we will get you out of here on time.

I know a lot of you are planning to go to the State Department event. I wanted to throw out a note here that we will end sharply at 11:00. You'll have plenty of time to make your way over to the State Department for the Space Enterprise Summit this afternoon. If you have any questions about that, we could help you there as well. We'll take a couple of minutes. I will invite my next panel up on stage.

[background conversations]

Krystal: All right, everyone. If everyone can go ahead and take their seats again, we're going to move on to our next panel. I am pleased to introduce our first speaker, Dr. Christoph Aubrecht. He is the senior geospatial strategist as well as ESA's representative to the World Bank.

He is going to kick off with a question on, Chris, what are some of the biggest innovations and changes you are seeing to help space data and applications that are becoming more integral to life on earth?

Christoph Aubrecht: Thanks, first of all, Krystal, and the Secure World Foundation for having me here. It's quite an interesting event. The topic is slightly different to what I am used to in attending conferences, but I'll try to make the link. I want to take a step back, and I think there's a lot of, as you mentioned, doom-and-gloom talk these days.

Let's try to be a little positive here when it comes to what impact we can have on life on earth. I want to start with a quote that maybe none of you have ever heard, but it may still fit. It's from Mustafa Kemal Ataturk, who is the founder of the new Turkish Republic, from the start of the 20th century. He said, "The future is in the skies."

Probably he was not really referring to satellites, but I can just use the quote to fit to our topic here. In that sense, the future really started a while ago, right? I'm really glad to have Ed also here on the panel, because I want to make another quote that refers to Google, actually. It's "We are never lost again." How do we actually interpret that?

With the start of Google Maps in 2005, nobody can actually claim to be lost again.

[laughter]

Christoph: I studied geography and cartography at the beginning before moving on to the remote sensing and observation side. Maps have always been important, and they still are, especially in terms of life on earth and in the sustainable development community. Maps are important, but I want to ask you a question, actually, what does maps and milk have in common? I know it's morning. Anybody?

No, everybody's still sleeping? What do maps and milk have in common? Nobody. The information is tangible, and it's wise to check the date.

[laughter]

Christoph: If you think this has been forward, Google Maps became so popular because it removed this sense of, I constantly need to buy a new map, and I'm always lost. This coincided with the up rise of commercial [inaudible 5:54] imagery in the early 2000's that provided the input beyond the traditional aerial photography that helped us create very detailed maps. Now we can do it more often.

I always like to have a few A's. My name starts with A, but a few A's that guide the discussion, so three A's on data, and that refers to your question. We need to make data available, accessible, and actionable. The best use of data is if the end user doesn't even think of the data anymore. Like Google Maps, nobody really thinks what goes into the creation of these maps. You just use it.

You just open your app and say, "OK, I want to go there." Another quote, as you may have noticed by now, I like quotes. One of our friend Jeff from Amazon, I guess most of you know him, Jeff Santo. He said, "Open data is happy data." You can interpret it at the way you want. Obviously, not everything has to be open. There's a lot of value in data that needs to be recognized, and not everything can be for free.

I'll get back to that in a little bit. How can we make all of this more integral as you said on applications, on the service side? In our sense, space agency we are the [inaudible 7:27] in the space agency community because we are a multi-governmental organization. We have 22-member states. Collaboration is adherence to our DNA.

We worked with other multi-governmental agencies, specifically in the sustainable environment domain for a number of years, with development banks particularly for about 10 years by now. We started with a lot of piloting exercising. We tried to showcase the value of satellite observation for answering certain development questions, provide solutions to certain development questions.

Back to your question, how can we make this more integral? How can we move from this piloting exercise to mainstreaming? I have another three A's for you. We need to raise awareness, available as possible. We need to make the end user accept it, so acceptance. If we really move from piloting to mainstreaming, the final goal is adoption. I had adoption before already, but this is in a different context.

If it's fully adopted in the regular processes that people in their day to day work do, then we can really talk about mainstream. It's really important in development to be aware that we as the tech community, we are obviously very excited about what we can offer, what we can do with great innovation as well. In the development community, we need to be very careful with tech push approaches.

We shouldn't tell them that this will save their lives. We should rather listen to them, what they need, and we may find a solution with the tools at our hands that can help them live a better life hopefully. We really need to move beyond the R&D phase here, and a lot of the space agencies often focus on R&D.

There is a lot of value in R&D, but if we talk about mainstreaming, if we talk about really integrating it into day to day life in the development community, then it's about operationalizing. [inaudible 9:46] can play a nice role in that regard because of our...As I said, we have 22-member states, and we have an interesting industrial policy. A very large share of our budget is spent back on industry, 85 percent to be clear.

In the collaborations that we have had with the development banks over the last 10 years, we've worked with more than a hundred service providers from more than 20 countries. This is really where it becomes sustainable because on the R&D side you cannot move it. You cannot keep doing it all the time. There will not be funding in the long run for it. You can try things. You can try things.

You can demonstrate things. Then somebody needs to take it up, and that's usually in the commercial sector if you can't make it open in terms of the tools an everything. That's important, and we need to also play in the translation role...

Man: You have a minute.

Christoph: One minute? A translation role between the space community and the development community. It's two different worlds, and I think all the other panelists can confirm that. We can try to play this translator function and help understand both sides how to work together. In that sense, it's really crucial to demonstrate the impact you can have.

For the end users, they must understand what this brings to them. It shouldn't just be fancy and nice, they should see the impact in economic terms and in societal terms. We need to make this valuable position and show that it's not just the data, but it's really the analytics, the services that you build on the data that there's a value in it. Not everything can be free.

I'll finish with another quote by Jeff. He said at Amazon they make free data cheaper, which is interesting, but if you think of it, it makes a lot of sense because, for example, the [inaudible 11:49] system that is a program in Europe that you can commission use of together [inaudible 11:55] . All the sentinel data is open and free, but that refers to availability and accessibility maybe.

In terms of really doing something with it, processing it, we distribute currently 150 terabytes per day. You need to handle it, that's not free, they cost something. All these considerations need to be considered in terms of really making an impact.

Krystal: Thank you for that kickoff. I wanted to let the panel take the lead here, but I do want to come back to what we're trying to remind everyone. A lot of us in the room, especially the few I know, we're space geeks. We like satellites. We like launchers. We like reading about these things. It's fun to us.

One of the things we always say at Secure World is we're not promoting space sustainability because we think space is cool, although we do. We're promoting it because it has a purpose because space assets protect the earth because space assets provide data that we need for so much of our lives today.

That's what we're trying to get at here in terms of what is that because I think we need to be reminded of that. Also, in a minute, we'll turn the conversation around, and we'll go, "OK. How do we take this narrative which we're going to hear here and build it into our conversation?"

A lot of the people that we're speaking to when we speak about space sustainability, they're not space geeks. When you're talking to regulators, when you're talking to someone who's so far down the value chain they still need to participate, they don't care. Space is cool. We get a bit of a slide there in general but not completely.

We need to make sure that this narrative is represented as well and that those challenges as well as those opportunities are taken advantage of and that those challenges are solved. Moving onto our next speaker, we have a lot of doctors. Dr. Danielle Wood is assistant professor at MIT as well as the director of the Space Enabled Research Group.

You are one of the panelists who actually do both things that we're talking about on this panel as well as space sustainability. I'd like to get your thoughts here on as we are talking about promoting space sustainability, how is this topic affect your work? How does what we're talking about here at this panel as well as the conference, what does that mean for you guys at MIT?

Danielle Wood: Thank you so much, and thank you to your whole team for organizing and for the invitation. I'll get started right up front to say that my thinking on combining earth sustainability, space sustainability has been greatly influenced by the Secure World last decade or so of being friends with [inaudible 14:18] .

I want to check in with the audience too and say good morning to you all and ask, how many of you have met at least one new person since you've been at this event? That's amazing. How many of you have learned at least one new thing?

[laughter]

Danielle: Let me say congratulations to the Secure World team. It's wonderful meeting with our old friend, but to see all the new connections being made is great. Thank you. I wanted to speak about the Space Enabled Research Group, which is a new team. I'm happy to take a moment and explain in more concrete terms what we do.

As professor at MIT, I had the privilege to create a team from scratch. Space Enabled, we have the mission to advance justice in earth's complex systems using designs enabled by space. If you want to hear more about that I have a little handout I can share with you afterward.

The mission basically says we want to make sure space technology is used to the maximum extent, helps support sustainable development on earth. We borrowed the definition from the United Nations that you heard referred to yesterday from the global goals of sustainable development. Sustainable goals is an excellent definition, what it means to make progress with life on earth.

We also had a whole [inaudible 15:24] that says we are both considering sustainability from the point of view of humans flourishing on earth and from the point view of environmental and social sustainability in orbit around the earth, onto the moon and to mars.

Wherever humans are going to have impact we have to ask, "How do we maintain sustainability and balance between progress and, of course, conservation and a sense of enabling our next generations to also enjoy the environment?"

We have the privilege in academia to think about all these levels, today's earth challenges, tomorrow's orbital problems, and coming challenges we'll have and opportunities we'll have sustainability even onto mars. Soon we'll need to write sustainability development goals for mars that our humans [inaudible 16:02] there as well. I can divide our research activities as a team at MIT into three areas.

The first asks how we ensure that development professionals and those who are working on today's STGs here on earth have the best use of space technology. The second is asking, how do we also ensure that space access is universal? Meaning for us justice also means every country, every community on earth would have access to the benefits of space regardless of their current industry and background.

Then also balancing that with the idea that where there's going to be sustainable access, we also have to have sustainable locations to go to. We think of space access and space sustainability as two sides of the same coin. The other area then is what we call value driven technology development. I'm an engineer. I have several engineering degrees, and I also have a policy degree.

I work closely with earth scientists and social scientists. We want to ask how engineers and designers of technology can integrate the thinking of social values such as reducing the impact of things like racism and other kinds of harm or overall thinking on [inaudible 17:02] technology that our software's [inaudible 17:04] . All of those are examples of our team.

I'll give a few concrete examples to make it even more clear. In the area of earth sustainability, I'm really honored to be working with NASA's Earth Science Application Program. They have actually funded projects directly on sustainable development goals. Their [inaudible 17:22] team just worked on their [inaudible 17:24] program in applied sciences.

They're directly saying, "You're working on sustainable development goal 14 or 15 in collaboration with national governments or regional leadership teams." We do have opportunities for private funding there. I have funding to work with teams and the government of Benin and in Ghana. They are looking particularly at SDG 15 which says enabling biodiversity for life on land.

In Ghana they're very concerned with issues around how to address illegal gold mining. It's a very high national priority across their government. We're working with the Ghana Fiscal Service, and they have the goal of counting how the country is doing in meeting all the SDGs, but they're targeting 15 of them now.

They are actually [inaudible 18:03] committee that will coordinate with representing their [inaudible 18:07] agency and their land ministry.

They are all going to come together and will ask, "How can that overall government team, whether universities or professionals [inaudible 18:15] better use satellite base data both from NASA, from Europe, from all over the world, in order to have better capability inside their national government to monitor illegal mining and to reduce its impacts.

Similarly, in the government of Benin, local companies there were asking how they can better understand forest fire impacts and look at techniques where adding low-cost sensors on the ground, but also satellite data to monitor and basic planning. These are very concrete questions, where the questions directly came from listening to the local people, listening to [inaudible 18:45] .

In this case, we first asked the teams, "What challenges do you see that you'd like to work on?" and, "Might it be that we can use data as a way to approach it?" On the side of value [inaudible 18:55] technology development, I want to highlight one of our recent graduates, a master's student named Christine Joseph. She's just finished her work here at MIT, and she'll be continually her professional work.

Her master's thesis asks the question, "How can we design the next generation of access to life and research, especially in low earth orbit, in the post-ISS era?" She looked at any proposals that are being pursued for how we might have both public and private research stations in low earth orbit beyond the current version of the space station.

Whether it's a new version of the same hardware or whether it's new hardware going up, our question was, will it be economically accessible and administratively accessible to countries all over the world? Today, if I want to collaborate with a country, a university, say, [inaudible 19:37] or I work in Benin or Ghana, we can easily collaborate together.

Because I have access to [inaudible 19:44] access to the US country, we can do research together on access, not just data. It's relatively low-cost. I'm actually in the middle of making applications, so I didn't get the opportunity as a university to go and do research, so that's wonderful. Our question was what will be the next generation of rules and opportunities?

She has developed a technique that can help us evaluate new proposals for access to microgravity research. Of course, in order for the whole world of access to do research on microgravity, we must also continue to make sure that space is [inaudible 20:13] available.

I want to give a final example. It's a collaboration, but I want to also [inaudible 20:19] . Our team had the privilege of following up when the World Economic Forum proposed the opportunity to have an organization create a space sustainability rating. We formed a team [inaudible 20:30], and collaborating with [inaudible 20:32] job and does excellent work in the [inaudible 20:36] system to visualize many objects in space.

We also collaborated with the [inaudible 20:40] team [inaudible 20:41] their support. We applied and then were invited to collaborate with [inaudible 20:46] office. We now have a joint team between World Development Forum, MIT, [inaudible 20:52] . It's a large team, that is international, and we are together formulating a space sustainability rating.

This idea was coming out of the concepts developed by the World Economic Forum's Global Future Council on Space. One of my colleagues who works on that team, Dr. [inaudible 21:07] .

We are so thankful that the global community that met together in that council developed this idea and invited a team to pursue it.

I want to say that there is, in this way, a very concrete action to invite incentives that will encourage companies to then commit, and to take credit, for anything they do that increases their responsibility in space.

We're still in the development process, so it in fact is an invitation to all of you, if you have ideas for how to have the right way to think about those measures, the activities a space operator does to be more responsible, please come see me or [inaudible 21:40] as well, you can raise your hands. We're both interested to hear your input. We'll have opportunities for cycles of input through workshops.

Especially those who are in this dialog, we appreciate your [inaudible 21:50] . We can get in touch with you privately or in meetings. Our goal is that it's really an internally-developed, community-driven idea, so that when it actually comes into fruition, many of us will already have had a chance to have input.

Thank you so much for the opportunity to share. We really want to do both academic research, but also work directly with many of you in government, academia and the non-profit world, to ensure that we are making progress together.

Krystal: Great, thank you Danielle. I also want to say that the benefits of space are potentially boundless. There aren't very many industries, projects, work around the world, that couldn't potentially benefit from greater access to space data, to integrating information, as well as the technologies we get from space, into their work.

How do we actually make that happen? It's exciting to hear what MIT is doing on that. Our next speaker...I'm going to skip to the end. I put them in the wrong order because it's been a very long week.

[laughter]

Krystal: ...is Mr. Carlos Enrique Alvarado. He's the former president and founder of the Central American Association for Aeronautics and Space, and the current director of the Costa Rican Society of Engineers and Architects. I think this flows really nicely from what Danielle was talking about.

Carlos, what I'd like to hear for you, and you already asked your own question with administrative writings done yesterday. If you have any comments [inaudible 23:15] your reaction there, I'd love to hear that as well, but what I'm really interested in hearing, what are the steps that the space world that all of us can take to make data and space capabilities more accessible to those who can have the most impact, particularly from a regional perspective?

Carlos Enrique Alvarado: Thank you very much. first and foremost, thank you very much for the opportunity. Thank you very much to [inaudible 23:36] and all of you for this great opportunity to talk about these important matters.

It is necessary first to identify the kinds of capabilities and applications that the non-space world requires in the context of facing the current global challenges. A good guide and definitely I believe this would, a good guide to make in creating the way to define priorities and decisions are the Sustainable Development Goals.

Focusing on those countries and regions with the greatest remaining challenges, those who can have the most impact of the space data and capabilities are the ones in need to solve basic human necessity and [inaudible 24:33] view to the need we agreed to this idea. What steps can the space world take to make data and capabilities more accessible?

First, the space world needs to understand that even though we are talking about a global value chain that requires economic and political stability and sustainability, there is a security threat for the entire world in terms of climate change and racing the clock. First, we should focus on solving those issues, creating accessibility and tools for building global facilities.

I will briefly mention a successful case of how can the non-space world [inaudible 25:28] these challenges benefiting from space world cooperation. The case of the first American satellite was a great way to demonstrate capabilities and know the structure for a specific and clear necessity for the region, the responsibility to monitor and measure natural resources in order to make informed policy decisions of their environment.

That's why when we launched the project in 2009, 10 years ago, our main concern was finding the right international space world partner. Those partners were sensitive enough to our necessity to learn more than to just buy a satellite [inaudible 26:20] .

I have to tell you that we found those partners, Japan, thanks to the [inaudible 26:29] of Technology and the Japanese Aerospace Exploration Agency as well as the US through the cooperation of NASA. Japan helped to train a team of Costa Ricans in [inaudible 26:42] for the project, and they gave advice during the entire mission.

They also coordinated with NASA [inaudible 26:50] to international space station because Costa Rica was a member of the United States. That was a way to get access to space capabilities.

Another good example is the experience of satellite data sharing that the US provides to the Central American region, specifically in Costa Rica the PRIAS program, which in English it means the Aero Remote and In Situ Sensor Research program with was created in 2003.

The program was later, as they were creating more and more results, consolidated as a laboratory with the mission of processing GIS and [inaudible 27:37] data using geospatial information.

The research project right now are currently monitoring changes in land use, forest coverings, analysis of growth of the urban areas, [inaudible 27:52] classification, community health, and many other applications that now are in progress in the country. What is the most difficult thing in all this? These capacities are now growing in the region.

Countries are starting to share what they learn with their neighbors. That's why the next step for us, for the [inaudible 28:15] , is the project Morazan, is the second step. It's a joint project between Costa Rica and Guatemala to help Honduras get to space and launch their first silo.

That's our way, as we now learn, now we are trying to engage our neighbors and pace the overall effect of the benefits that we are talking about. Something else for the sustainability of the global value chain is that in the future, this condition will bring the environment to create more value and generate economic sustainability for space activities in the region.

In our case, I'm very, very happy and proud to say that this seed is germinating in Costa Rica. There is already an aerospace cluster of companies. I was one of the persons that around 10 years ago, we launched the first study of the conditions and possibility for Costa Rica to being part of [inaudible 29:29] how, what we work as a country to attract foreign investment.

Now, Costa Rica has one of the biggest clusters for the medical device industry that requires very, very high technical technology capacities. We have 7 of the top 10 companies of the world working in the country in the medical device industry and life science industry. We aim also to become a global player in the world center for space industry.

We want all of you investing in the country, in the region, too. Our companies are learning, they are preparing. There are up to the standards, they want to be players. Of course, the country needs to continue attracting more foreigner investment, more engagement with these global value chains.

I definitely think that these examples are a loophole to creating real, positive, and long-term impact ensuring sustainability for space activities.

Krystal: Thank you, Carlos. I think it's easy to not go through the steps that a new actor has to go through. In a minute, I want to return to that question, and even ask you, what was it like to be a new actor, and what did you have to think about? Before we do that, our last, and certainly not least, speaker is Ed Parsons from Google.

I'm not sure if anyone else here knows this, but the State Department has personally distinguished Lee Schwartz, his title is the Geographer of State. Well, not to be outdone, Google also has their very own the geographer." Ed is the geospatial technologist of Google, and his responsibility is integrating geography across a variety of areas.

You have a completely different perspective here. You and I have run into each other in different places than the normal space world. I'd really like to hear of your perspective of a company that essentially operates across global fields of vision, I suppose you could say.

How can we continue to break down the silos between the space world and the non-space world? Where have you really seen the opportunities for that?

Ed Parsons: Some very good questions. Krystal, I'll be joining everyone else in thanking you for the opportunity to be here. I'm not from the space world, as she said. I'm a geographer, my tools of trade are the paper map, as we heard about earlier, obviously now with the additional version of that. I am, of course, a space geek, an enthusiast.

Someone showed that I flew across the Atlantic about 10 years ago to see one of the last shuttle launches. Very lucky, that they actually launched on time and I was there to see it. It was a very emotional moment. Actually, I understand the appeal of large, very explosive machines.

[laughter]

Ed: Being a rocket scientist isn't helpful in many ways, because actually, Google is a concealer rather than a user of space technology. We are very much [inaudible 32:47] . Well, how can this help our users? Our users are literally everybody. That's who we [inaudible 32:55] our services.

Actually, we are perhaps more successful than we might imagine at the process of bringing space technology into what we do on a day-by-day basis. I'm a big fan of Mark Weiser, he was the chief scientist at the Palo Alto Research Center, PARC, the place where much of this IT technology that we all use today was developed in the late '70s, early '80s.

He said that the most transformative, the most fundamental technologies we use end up disappearing. They become part of the fabric of our lives, and we don't think about them very much. When you think about electricity, you don't think about all of the activities that go on behind the switch when you switch on your electric light.

In the same way, we use space technology all of the time in our everyday lives, particularly through these things, through smartphones. I think that we'd probably be better branding these things space phones, because fundamentally, they are built on the technologies that we are talking about here. From a concealer point of view, from a Google point of view, we basically do technologies that you would imagine.

We're very much into positioning and timing, so GNSS. We haven't spoken very much about GNSS as an important technology in a sustainability sense here at the conference, but it's very important. It's fundamental to making this thing smart. Knowing where it is all the time, having that little blue dot that identifies where you are is a fundamentally transformative technology.

It [inaudible 34:37] and never being lost. That's an amazing change in society, and particularly for perhaps members of society that are more at risk moving around, actually knowing where you are, and being able to communicate [inaudible 34:53] to other people is a truly important technology. Then, of course, earth observation.

Earth observation means a couple things to us. Earth observation has that very consumer focus of the satellite view in Google Maps or Google Earth. Of course, the reality of it is in most cases, you are looking at aerial photography, but we won't talk about that too much.

The other part is the impact that it can have in terms of reporting environments or monitoring. We are looking at this, as is often the case with people, from an interesting technology challenge. There's a real paradigm shift happening here with earth observation. I started my career in the late 1980s, early 1990s in this space by doing a masters in Applied Remote Sensing.

At the time, the new FanGo technology was the Landsat for Magic Mapper -- this is how long ago now folks -- where you have your marvelous 30-meter resolution in certain spectral balance. I used to literally spend a whole night waiting for this stage of the offloading of the centerpiece of capacity tapes onto a dedicated computer that was for image processing.

It would take all night to upload a five draw by five draw extract to the image it needs for the processing. If you think about it, the space component of earth observation hasn't really changed that much since Landsat. Maybe I'm drawing too big a statement there, but actually, we're still putting up a lot of electronics with a sensor on it and then we're beaming down the reflections of life from those sensors.

What has fundamentally changed is what happens on the planet in terms of how we deal with that imagery. We're no longer dealing with computing capacity tapes. We no longer have to have dedicated processing capabilities. I can do now from my mobile phone in less than a second what took me a whole night to do in the 1990s.

That's where the big change has come, and that's where I think we've been most successful at making space and this technology much more accessible. Of course, that success, as I said from the Mark Weiser quote, means that it's largely invisible to us. We can work to try and identify those differences.

A lot of it is down to education. A lot of it is about us explaining, "Actually this very useful, actionable piece of information that makes a difference to you has come from space technology." If you ask most people about space, they'll know about rocket launches, because they're always on the television. The only other thing they'll be able to tell you is that space is very, very big.

That comes from Douglas Adams, I think. The other thing is that no one can hear you scream in space.

[laughter]

Ed: Not particularly useful, really. Actually, if we focus a bit more, we can say, actually, when we've done the calculations, having this information on your mobile device, for example, about the traffic conditions that are happening in real time around you, can save you as an average family in the United States $500 a year.

That's the actual value that means to you in terms of time saved, and spending much less money on gas, being sitting in a traffic jam. That's a real concrete actionable number that means something to people. That's what we should be talking about. It's not about rockets, it's not about satellites, it's actually, it saves me time, and it saves me money.

In the longer term, there is this weak spot, this paradigm shift in terms of earth's observation, where we can combine the constellations that are providing us with near real time imagery, with machine learning to produce really valuable actionable information. We can say, the first action is happening illegally, in this position, now. Go out and deal with it.

Something we couldn't even contemplate doing just five years ago. Because of the new constellations we have, because of machine learning, we can make those decisions in near real time and then do something about it. We can look at ad-tech, for example. We can look at much more valuable, much more sophisticated use of nitrates in terms of fertilizers.

Nitric oxide as a greenhouse gas an order of magnitude more powerful than carbon dioxide. If we could reduce the nitrates we use in agriculture, that's waging control of global warming. That's something that comes through the combination of imagery in the cloud being processed automatically.

Moving away from that mindset we've had in the past, where we thought about the product of an observation as a pixel. Actually, we need to think of the product of an observation, as information that is actionable and usable in real time. That's opening up all sorts of different application areas, insurance and finance, where we're looking at a much more compliant use of technology.

Fundamentally, going back to answering Krystal's question. The way that we joined the two together is to make it easier, is to make it less of space rocket science. To make it much more about the information products that we're producing. To make those information products easily accessible part of existing workflow or activities that we already do. That's the key.

That's why as an organization, Google is involved in this, how our whole mission in life is to make information more accessible and useful. We see space primarily as an industry that creates information, and then that sucks into the way that we operate. Thank you.

Krystal: Thank you, Ed. As you can tell, I don't have to do a lot of work asking them questions. They all see me here. We're going to steal a page from my coworker's book and do two quick rounds. I have a lot of really great questions from there, so I'm going to try to combine them into two questions. The first one is I want you guys to do my job for me.

In case anyone doesn't know I'm director of space allocations. It's my job to bring what we just talked about here into the space world, into these larger conversations.

I want to hear from each of you about how can we better represent everything we just talked about to space world, to the non-space world, people that need to know about these things, to understand this invisible technology in a lot of ways. How do we bring this narrative to a larger

conversation? That's one of the reasons that if we're going to do anything about space sustainability to begin with.

I have no particular order. Danielle maybe?

Danielle: I'll answer by describing how I form my team and how I try and pursue all of the projects that I do that are about this translation we talked about, from single development goal needs into action. The team that I bring together includes researchers and graduate students from six fields.

We start with design thinking because that means asking what the humans involved actually needs or what the environment actually needs. We include artists, people who are there to help us celebrate what it means to be human and how humans communicate with each other.

We always include social science, either reading excellent textbooks and excellent work of history, anthropology, economics, or collaborating directly with social scientists. We are complex system thinkers. My PhD studies is in engineering. We conceive of the world as full of complex systems where technology interacts with the environment and parts that it plays, the ways that it can improve.

We also build hardware and software tools that can help solve problems having listened carefully through design and the art phase. We also with data science tools like the kind you mentioned. Making sure we always these kinds of thought, maybe the list changes for you, but having always this variety of thinking is the starting point for making progress in these kinds of important challenges.

I think of climate change and then the parallel challenges of loss of sustainability in orbit as these two couple challenges where everyone would like to blame someone else and no one wants to take responsibility.

If we can pilot to everyone the need for both the [inaudible 43:15] and the human race for climate change and for the need to make an orbital sustainability project, we know we need all these kind of thinking to consider these important challenges of our era.

Krystal: We don't usually make the exact parallel, but the reality is that we don't want the space environment to become what happened to many of our terrestrial environments. We're absolutely trying to avoid that. Carlos, what do you think?

Carlos: First, I think we need first to work on this [inaudible 43:51] especially in the development world. We need to educate politicians in order to translate this message to people. Also [inaudible 44:03] ways to create public awareness through inspirational experiences.

For example, I can mention that is was [inaudible 44:15] in 2016 when the [inaudible 44:18] was the host of the United Nations Human and Space Technology Workshop. It was an event

[inaudible 44:28] thanks to the cooperation with the United Nations and this team of stakeholders, important actors from the space sector in the country.

We have, for example, astronauts, and they were talking about the future of human and space technology. The countries of that, it was a good way also to connect the [inaudible 44:55] of that workshop to the people. What we decided, we created, and we organized a public event in the national stage.

We joined more than 10,000 students from the public's allocation systems to learn from the experience of all the astronauts, the [inaudible 45:14] and the cosmonauts that went to the county. That's creating now leverage for the future, and that's the way that when the discussion on public policy and there is the desire to create, build, and invest more in the country in space.

That's a way to invest because in the future, those children that were inspired, they will be dreaming to have the country being an active player of space. More than that, they will be aware of the benefits. The discussion will move from the public's perspective to say, "No," Costa Rica or any country to say it is not only a matter of spending on launching rockets.

It is a matter of survival, for the future for our challenges because the impact of the global [inaudible 46:09] society is one of the main challenges for societies like ours.

Krystal: [inaudible 46:17] have great building average. Chris, you said it's the nexus of these two worlds, how do you convey what's happening at the World Bank back east then? How we can do this in a broader level?

Christoph: Thanks. That's a very good question. I think that I want to take one step back. Actually, what you just said, two phrases really struck me. First of all, educate politicians, and second inspire the kids. I think it's really key.

If we look at the discussion that we have at the World Bank, that we have at the UN, it's really about the policy making. That's one of the angles why we as ESA have been engaging, or have been increasingly trying to engage very tightly with the development banks. Not necessarily for the sake of working with the banks, but actually for getting into the continuous policy dialogue at the country level.

For a development bank, its client is the country. If you look at the World Bank, of course there's also the private sector [inaudible 47:21] the IFC and the other development banks, to regional ones have similar ones. Let's focus on the public sector. One of this added value, proposition is really getting into this continuous policy dialogues.

What the World Bank does and other development banks have similar systems, they have an approach they call Country Partnership Framework where they sit together with the governments that they work with and define what are the country specific priorities in terms of developments. They've changed [inaudible 47:53] , not every country has the same priorities.

If we as the space community can actually be part of this discussion from the very beginning, we can help them use space technology, use data services, to make better decisions in terms of target their investments differently. Do the implementation differently, help them with monitoring devaluation, help them with impact assessment, the whole value chain.

I think that's really where we can make a difference. Many of these people don't really understand what's possible with space. There's an iteration that needs to be done and then that's where we can help. I think the STGs that are cited frequently important are a great framework, but it's also only part of the system. It is also a risk that we then only focus on these 17 goals, and try to set up the recording systems on this.

There are a lot of facets that may not fully be covered by the various indicators. That get lost in-between the lines. I think the countries really know what they need. We try to help them along the way to find solutions for their [inaudible 49:05] .

Krystal: I'm actually really interested, I was hoping to ask one more question about what you guys think is the most interesting, untapped space application. Since I'm in charge, I also have to keep myself to my strict time limits.

[laughter]

Krystal: I'm going to let you have a last word on this topic. Google cares about space sustainability, in my opinion everybody should care about space sustainability. Would you agree with that? How do we bring organizations like Google into this conversation that we are having here, other than just me inviting you?

Ed: Being invited, it's obviously a major part of that. If you do this next year please do invite me again.

[laughter]

Ed: I think it is from the broader non-space actor community, there is largely about education and about lanes to say when a lot of the way that the rest of the world does perceive the space industry isn't about rockets and it's about expensive, very sophisticated machines that, they're inaccessible to most people.

I think what we need to do is to work much harder in saying that one space is deeply embedded in all of our lives, and then to make products and services that are more accessible. Therefore, as a result of that, the importance of sustainability in the space industry becomes more and more obvious.

We've done and in various countries around world, particularly focused on GNSS and looked at the impact of GNSS being reduced in capability or completely removed. We warn that GNSS is a relatively fragile system. It's easily impacted by space weather, it could be impacted by issues in terms of the use of different radio frequencies, all sorts of issues arise.

It's worth billions, billions of euros or billions of dollars. Having those issue raised and presented to decision makers in government and to operational planners is a way that you can highlight these impacts. It's I suppose a case of drawing people's attention to just how valuable space is to our day-to-day lives.

That therefore, raises the importance of making sure the industry remains sustainable. It is I suppose joining those parallels between the environment. We are very concerned about the environment on our own planet. We know that we have no alternative in the foreseeable future to living on our planet. When we have no alternative to space, if we want to continue doing what we do we have to look up [inaudible 51:53] in the same way.

[laughter]

Krystal: All right. Thank you all so much for coming.

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