The Future of Space Safety

Speakers

- Opening Remarks: **Peter Martinez**, Executive Director, Secure World Foundation
- Keynotes:
  - **Johann-Dietrich Wörner**, Director General, European Space Agency
  - **Patrick Besha**, Senior Policy Advisor in the Office of the Administrator at NASA Headquarters
- Panelists:
  - **Jim Cooper**, Senior Systems Engineer, Space Situational Awareness, Analytical Graphics, Inc.
  - **Todd Harrison**, Director, CSIS Aerospace Security Project and Defense Budget Analysis
  - **Diane Howard**, Professor of Commercial Space Operations/Spaceflight Ops, Embry-Riddle Aeronautical University
  - **Bill Murtagh**, Program Coordinator, NOAA Space Weather Prediction Center
  - **Charity Weeden**, US Managing Representative, Astroscale
- Moderator: **Victoria Samson**, Washington Office Director, Secure World Foundation

Peter Martinez: [00:23] Good afternoon everyone. Welcome to the Carnegie Endowment for International Peace for our panel event on the future of space safety, organized jointly by a Secure World Foundation and the European Space Agency.

[00:38] My name is Peter Martinez. I'm the executive director of the Secure World Foundation. And I have the honor to provide a few opening remarks for our panel event here this afternoon.

[00:49] I know this is an extremely busy time of the year here in DC. There's a wide variety of events and so I really appreciate that you've chosen to come here this afternoon instead of attending one of the other equally exciting competing events out there. So thank you and, and welcome to all of you.

[01:06] For those of you who aren't familiar with Secure World Foundation, we are a private operating foundation with offices here in Washington DC and headquartered in Colorado. But we have an international footprint of activities that span six continents and um, just recently joined the organization, um, about a month ago and I keep being amazed at the amount of um, activities the number of activities that our uh, fairly small team complete, accomplishes every year and this is one of them.

[01:38] The mission of Secure World Foundation is to work with governments, industry and international organizations and civil society to promote ideas and actions to achieve the secure and sustainable and peaceful uses of outer space. And today's event is an example of one of the ways in which we work to achieve our mission.

[01:59] We're very proud to have today's event co organized by Secure World Foundation and the European Space Agency on the important topic of the future of space safety. As we're all aware, the number of actors uh, in the space environment has increased enormously.

[02:18] But not only the number of actors, also the diversity of actors, um. Actors from um, awidely varying number of countries, different capabilities.

[02:28] And we're also seeing the rise of a large number of new kinds of space applications that uh, we haven't seen in the past. Some of those still to be proven on orbit, but these raise um, enormous hopes but also, um, concerns for the safety, security and sustainability of space operations.

[02:52] And so these developments have, um, increased the number of stakeholders interested in preserving the orbital environment. And this is something that I've witnessed during the, um, eight or so years when I was chairing the working group on long term sustainability in COUPOS.

[03:09] That's, uh, in the beginning, in the early days of those discussions. Um, the discussions were dominated by a small number of countries. But as the process went on the, uh, active participation increased enormously. And this is a good thing because place, space sustainability is a concern of, um, all nations and not just a few advanced space faring nations.

[03:33] And so as governments and their many agencies seek to preserve access to the benefits of space, how can collaboration reduce redundancies and avoid the complications of differing definitions, priorities and data standards. And these are some of the questions that our panel will address today.

[03:53] I have the honor and pleasure to introduce two of our keynote speakers for today. The first is Professor Jan Wörner, Director General of the European Space Agency. Jan Wörner has been the Director General of ESA since the 1st of July 2015 and before that he was the chairman of the executive board of DLR. And, um, it's a great pleasure, Jan, to welcome you here.

[04:16] And, uh, I would just like to take the opportunity to, um, thank you and ESA for the very, um, strong support that ESA provided for the LTS guidelines and COPUOS during all the years that we were negotiating and it's just really appreciated and I've never had the chance to express that to you personally.

[04:37] Our second keynote speaker is Dr. Patrick Besha, who's a Senior Policy Adviser to the administrator of NASA. He provides expert analysis and directs research studies on a variety of topics, with recent efforts focused on global space exploration, economic and policy evaluations. Um, uh, and also on major civil commercial space initiatives and, um, uh, national space security issues and international relations.

[05:08] He will be replacing Tom Cremins, who was on our agenda today but was unfortunately unable to attend because he's not been well. So, um, Dr. Beshir, thank you very much for stepping up at short notice to, to take over.

[05:23] So, um, turning now to the substance of today's panel event ESA's concept of space safety operations. Oh s , sorry. ESA's concept of space safety encompasses different efforts that um, range, that a range of U.S. actors are engaged with, so specifically we're talking about space situational awareness which includes space weather, planetary defense and debris remediation. And the purpose of today's event is to hear from ESA and to find out the similarities and differences in approach to the concepts of space safety within the European and the U.S. space enterprises.

[06:02] And Jan and Tom will provide the um, perspectives of their organizations. After the two keynotes, we will transition to the panel which will draw out the nuances of the different communities engaged on these topics within the U.S.

[06:19] And our panelists will be Jim Cooper of Analytical Graphics. He will speak on the state of space debris as an environmental threat.

[06:30] Bill Murtagh of NOAA, who will speak on space weather as an environmental threat.

[06:36] Diane Howard of the International Institute of Space Law. Diane will speak to us on the legal and policy challenges to better space safety.

[06:44] Charity Weeden of Astroscale. She will speak to us on a necessity to...Sorry, speak on space as a necessity to a thriving commercial space market. I think Charity, there's a typo here in my brief notes. [laughter]

[07:01] Um, and uh, Todd Harrison of the Center for Strategic and International Studies, who will address the national security challenges to, uh, um, improving space safety. So welcome to all of you. And thank you for sharing your expertise with us this afternoon. And over to our first keynote speaker.

[07:22] [background music]

Johann Deitrich Wörner: [07:22] I will do in that. OK. So I will start again. I will talk about space safety from our perspective and I'm really feel very much honored that I can be here and uh talk to you about what we are doing. And I start this, uh with a clear message, uh, to...This is the picture I'm always using. You know it of course as uh, one of the most beautiful pictures of our Earth. Our Earth is over there. So that's clear.

[07:50] That's our Earth. Not the most important point in the universe but it's the most important point for us in this universe so far. There is no Plan B and no planet B so far.

[08:00] And therefore we should concentrate on this one. And we should also take care of the planet because it is endangered. And as for that um, we are using space right now for lot of uh, tackling of global challenges.

[08:14] You see here a list. I will not go in all these different challenges but it's clear now I'm standing in front of you all the time. That's also very nice.

[08:23] Each and every one is a global challenge and, and, uh, we can tackle them with space. I don't put a priority list over here. But what is clear for me, that there is one very special global challenge as well and this is curiosity.

[08:37] Of course, I will not go through all of this, but it's clear that space today is an infrastructure covering all of these different aspects. So space is something we need to secure for the future.

[08:50] And as we know from the past, competition is a good driver. Who would run in less than 10 seconds for 100 meters without competition? I would not do it. I would take either a bicycle or car.

[09:02] But people, because of sports, because of um, competition, they are so fast. So, competition is a driver. We should never forget about that.

[09:11] But, there is a but, and the but is co operation is an enabler. Through co operation we can do things which we would not do alone. And uh, that means not only with money, but also with co operation on topics.

[09:24] Now, safety and security and you see the situation is that we in ESA right now, since about uh, uh, two years now, we had in 2016, we had a ministerial conference. We have every three years a ministerial conference where the ministers of all our 22 member states come together.

[09:42] And then I have to propose what to do. And then they give me the money or they don't give me the money. That's then my problem.

[09:49] So we had it in 2016 and we said we should have safety and security in our day to day work. And um, first of all, we had to explain what we mean to our member states because in, for instance in German language safety and security is only one word sicherheit, but in English, you know, it especially that is something different. So what is ESA is doing is of course, science and exploration of course applications like Earth observation, navigation, telecommunication.

[10:20] We are doing enabling and support, developing new launches, but also doing operations and technologies. But as you can see here, that's the fourth pillar which we now edit into our program and this is safety and security. And safety and security should cover two main areas plus one, which we call more or less quality assurance.

[10:42] This is cyber security. Without cyber security it makes no sense to, to go this or that way. So we have on the left hand side that what we are talking today, it's about space safety where the threat is originated in space. And the other one is safety and security applications, where the threat is originating on the surface of the Earth.

[11:03] But both, for both, we are using space as an instrument. Uh, and therefore, if you look into details, we have on the left hand side and it was already mentioned we have the space weather. We have, [clears throat] we have debris. We have planetary defense, near Earth objects, collision avoidance, autonomous collision avoidance, all of this.

[11:21] And we are right now preparing a single, what we call envelope program for all these space safety aspects to give them, to propose to our member states next year and to get then hopefully, the money we need for that. And on the right hand side, you see there's safety and security applications which is covering maritime security, food security.

[11:42] Also in case of any tsunami, earthquake or flooding to use a global, uh, society to act c , against it. And again, the cyber security is seen over here.

[11:55] I will say a few words to this, but also we are discussing today about space safety but just to show um, what we are doing over there. And when I go to layman's I always have to explain what big data is, because I don't know whether it's here in the same room as the same problem. But no , normally people believe uh, big data means a lot of data, and this is totally wrong.

[12:16] If I have from you, your name, your credit card number, the expiration date, and on the far side of the card also has a security code I have only four data, but it's big data because I have your money. And therefore, this is big data, putting together the um, the data from different sources.

[12:35] Whether it's many data or not doesn't matter. But this is big data and we're using it for very many purposes, especially, especially in safety and security applications. Just one example for, uh, the case of safety.

[12:50] This is a train accident. And, uh, this was, uh, a collision, two trains on the same track in the opposite direction.

[12:57] And by using, for instance, satellite navigation systems, uh, and some communication, uh, that means using different data from different sources, You can have a railway collision avoidance system like we have with train, with planes, for instance, one case for safety applications.

[13:14] Now, the security application is this one. This is not the picture of the Earth from a satellite. It is data from, from, uh, from ships, the automatic, uh, identification signals. And each and every dot over here is one ship. So you see that the continents only in the rivers, some dots. So this is one data. This is one set of data.

[13:37] So, wherever you get this information you know that there is a ship sending this data. So it should be more or less a friendly ship, or at least a authorized ship.

[13:48] Now if you, you see at the same time, for instance, radar satellites, or optical satellites, and compare the data from both sources, and if you get the difference between the optical data and the radar data, then you should look a little bit more in detail to it. For instance, this case it was a hijacked ship.

[14:06] You could see it from the, on the radar from the, from the, from the satellites, but you could not see an automated identification signal. So this is just one example for security applications and we are trying to do all of this uhu h, this very special activities.

[14:23] Now, coming back to space safety, I'm sure you know this one. For me, it was Sandra Bullock and the other one was this guy who is selling espresso.

[14:33] [laughter]

Jan: [14:33] But uh, there was another actor as well. And, uh, and this was science fiction to be seen. Science fiction, but you all know that we are very close to this situation because we have more than uh, 750,000 particles space debris of a size of less than half, uh, bigger than half an inch.

[14:54] And as all of them are flying in vacuum, what we need is a vacuum cleaner. And this is something we have to do. And to show that this is not only science fiction, just one example. This is one of our Sentinel satellite, Sentinel 1A, a radar satellite. And in April 2014 it was launched.

[15:14] We had very nice selfie of the satellite showing the uh, solar panels. And just two years later, we suddenly saw a drop in the electric production. And, uh, we then saw that over here there was impact of a very tiny particle hitting this satellite and by that, destroying partially the solar panel, but it's still working.

[15:36] But therefore, it's not any longer just a question of science fiction. Another example, this one we know. The upper stages, fairings, and all of this usually are going back to the Earth. And depending on how cautious you take this action, it may hit also the ground. It may hit also people or buildings.

[15:59] Normally, people are saying this is stupid because the probability is so small, you don't have to take care of it. But if you tell the farmer of this building over here it's just a question of probability, he will be very angry, I can tell you. As you see it with his face, he was not happy at all.

[16:17] And then we have the issue of collision in space. You had the ve , very famous collision between Iridium 33 and Cosmos 2251 in 2009. It was not only a question of collision but because of the collision, many more particles were produced, so it's really a, a dangerous situation.

[16:37] And now I know this one is not loved, especially by young people what I'm saying right now. Personally, I was also not so happy when I saw this example. Because for me, this is a nice car, maybe. Yes, it was a nice activity to, to have a successful launch of that.

[16:56] But there is no function as a satellite and there is no automatic removal capacity onboard. So for me, this is really a little bit difficult situation, having a Tesla in space.

[17:08] Now what we are trying in ESA, we are really looking for in orbit servicing and debris removal. For that part, we said for all what we are doing we gave our, uh, ministers, uh, nice words. So on this case, we say stay clean. The vacuum cleaner, again, was a double meaning the cleaning of the vacuum, not cleaning by vacuum.

[17:32] And, and we are trying to do this in a totally different way. I would come back to that in a minute and not in the traditional way of giving jobs to industry, procurement and the contract, and then they should do it and, uh, er, we do the micromanagement to get to some success.

[17:50] Mega constellation is a very nice activity. Yes, I'm happy about it, but I have also some problems. And if you ask the people producing mega constellations, thousands of conste , satellites are planned, and if you ask them, "How can you afford to do so?" they usually answer, "Yes, we built very cheap satellites."

"[18:09] OK," I say, "How, how do you make them cheaper?" "Ya, we reduce a little bit, uh, the reliability, by just 10 percent." Meaning, if you have thousands of satellites, you have hundreds of unreliable satellites. And this is, uh, also for me, an issue.

[18:24] Therefore we need also, some legal activities in that direction, in order to make sure that the mega constellations are not endangering in the future, the whole infrastructure space which we have.

[18:35] And therefore, there are different possibilities. One possibility is to have an automatic de orbiting system, when of course, uh, o , one thing which is also important, to have automatic satellite collision avoidance systems like in planes, like with the trains I showed before, and maybe artificial intelligence is in that, uh, direction, a very good solution.

[18:56] And of course, the word which is, uh, used here in the US ve , very frequently, na , that namely is space traffic management, should also take care of that. So my opinion is, and maybe ca , we can discuss about that later on, I think we should exchange on a global basis, SST data.

[19:13] I know, uh, I see also some people in uniform over here, that there was some concern, concerning military satellites, but where is the sense of knowing, uh, only the civil satellites, and then having a collision with the military satellites? I don't want to know what the military satellites are doing, but it's better to know about their orbits. This is, uh, my personal opinion, but, uh, we can discuss about that.

[19:36] Then we need technolog , uh, techno , tech, technical solutions for debris avoidance, and we need legal activities for future debris avoidance, uh, automatic de orbiting and similar like that. But this

is only part of, um, the, uh, uh, space safety, uh, issue. Another thing is, of course, the natural particles which are flying around in orbit. And here, a short movie.

[19:59] [background music]

[19:59] [recorded content plays]

Narrator: [20:00] The top story today remains last week's discovery of an asteroid as big as a city block that is heading for Earth, and according to initial predictions, is forecast to hit somewhere between Tokyo and Copenhagen, just 24 days from now. Simulations indicate the impact will provide enough energy to destroy a city.

[20:22] [recorded content ends]

Jan: [20:24] This is, of course, a fiction, but we were already in the past, close to it, and we are always again close to it. So you know Chelyabinsk, in 2013, it, uh, this meteorite exploded in, in the air, about 1,500 injuries. So it is, uh, uh, really a concrete concern.

[20:44] This was a tiny one. Uh, quite recently, they found another one, um, a, a crater in Greenland, um, which in, uh, where, it's probably 31 kilometers diameter crater was, uh, developed by an impact, uh, of a meteor.

[21:01] And we have worldwide, we have a lot of them, uh, also in the United States, all over the world. We have confirmed, um, impact craters on Earth. And the probability and when I talk about this to European politicians, they always ask the same question, "Will it happen during my term?" This is...

[21:19] [laughter]

Jan: [21:19] the very clear question. Um, and here you see the statistics. Uh, if you were to think about, let's have Tunguska as an example, it's typically all 300 years. This is really a very high probability, every 300 years.

[21:33] And of course, you cannot say, "It was in 1908, so the next time it will be only in 2208, uh, at the same date." It's not. From a probability point of view, this is really a high number, so this is really dangerous.

[21:48] And it always happens. Asteroid 2017 slips, uh, through Earth's defense, 2017. We had another one, uh, which in 2017, was very close to the Earth. And this is a picture from last week, uh, from Austria.

[22:03] Uh, I like the picture, at least because of the quality of the picture, and Austria is a nice country. But again, it happens. It happens, it happens, it happens.

[22:11] And it's, and it's not only that we can observe the asteroids in our solar system, sometimes we have visitors coming from elsewhere. Um, and in this case it was 'Oumuamua, an interstellar visitor, which was even thought at the beginning, maybe it's a alien spacecraft.

[22:29] But this may happen, um, and therefore we have really an issue about that. And if this happens in the future, we should be at least prepared. Um, and, um, the solution which is in the next slide is not

the real solution, to say, we go to the moon and observe the whole story from there. And Bruce Willis will not do it again.

[22:49] [laughter]

Jan: [22:49] So we better prepare something, and to play billiard in space is one of the solutions. We are looking into that together with our, uh, American friends, uh, with NASA. Uh, so they are on the way to hit Didymon Didymon, a small moon of Didymos.

[23:05] And we are planning to go there and look afterwards, what is that crater, what is the deflection, what is the rotation, because the center of gravity of, uh, um, asteroid is not in the middle automatically, and therefore we look to that.

[23:18] Solar flares is another issue. Unfortunately, we cannot do anything, uh, against it, but we know that solar flares is really endangering our modern society. This is today, meaning satellites, uh, avionics, even on ground, um, it can, um, really come to, uh, big, uh, problems.

[23:41] Um, the it happened in 2, uh, 19, uh, 1859, a strong, uh, solar flare hit your country. At that time, we had no Internet, no, uh, electric network, but we had, um, um, a telegraph system. And it's, uh, said I don't know whether it's a legend or not that even paper and the, the telegraph machine were burning. So it's really, it, it is a danger.

[24:06] And there was another one in, uh, 9, 1989, which hit, uh, Canada and, uh, even there was a grid failure of the electric grids. So it's, it's really a danger. And, uh, I heard also, always recently, uh, very recently, that in the Vietnam War, uh, War, even mines were exploded, uh, through solar flares. So it is really a danger and we have to take care of that.

[24:33] We are right now trying to plan a mission, together with United States of America, because we believe L1 is a very nice place to look, to see what is happening, but from L5 you can see better the speed. So you see the orientation from L1, from L5 you see the speed, and by that we can do, uh, forecast, uh, also for, uh, um, something like that.

[24:57] So overall, what we have to do is, we have, uh, to have a detection of the threat and the analysis, and then to have some protection, to have some mitigation, and of course, also as always, also afterwards, responding with crisis management and recovery.

[25:11] So how do we do this final part? In the past, everything what we did in space, we did through traditional projects, meaning the agencies had money, gave it to industry, and then through micromanagement, realized, uh, uh, the one or the other project.

[25:29] This was a successful story. We should not say it wasn't successful, but we have a changing environment. As you mentioned already, we have more private actors right now, we have more space faring nations, and therefore we have also a different race.

[25:41] So for instance, public private partnership projects, or even turn key projects, where we offer just a request. We ask a request and industry can follow that request, and we get the final result afterwards.

[25:55] And just to show you in that respect, how we are doing it, so for instance, uh, Aeolus, which was a spacecraft we launched this summer, that was, it's measuring the wind speed of wind, the speed of

wind on the surface a very sophisticated, uh, satellite. This was done in the c , traditional way, uh, as an agency, with procurement, with industry, etc.

[26:18] Public private partnership this is what we're doing to develop new generation, uh, platforms for geostationary telecom satellites. And on the right hand side, I come back to what I had mentioned earlier in orbit servicing and debris removal.

[26:32] So we are right now in a process, where we ask industry to bring down one ESA satellite, but at the same time, to put in that offer, um, uh, the information, how they will make business out of that. Servicing and getting money not from us, but from others.

[26:51] So they...Immediately, some of the companies ask, "How much money do we get afterwards?" And we said, "No, zero. You have to give an offer where you bring down our satellite. For that we will pay you, but you have to show us that you have, afterwards, a business case, and make something out of it."

[27:06] We had about I have to look to Kiara 13 applications. We down selected them now to six. We will go down to two, and then we will buy that, uh, we will go to all our member states to ge , get the funding.

[27:19] That means also, for the agencies, we are in a shift of paradigm. We are coming from the agency part in the, in the past, to be a partner for projects, but sometimes only broker, meaning we are putting together different industries to do something, even without our money, which is an interesting, uh, role mediator, facilitator, and enabler.

[27:40] This concludes my presentation. Thank you very much for your attention.

[27:43] [applause]

Dr. Patrick Besha: [27:48] Hey, good afternoon to, um, to Sec , Secure World Foundation and the Carnegie, um, Endowment. Um, that was a fantastic keynote, uh, Johann Wörner, uh, very comprehensive overview of the field, as well as the comprehensive overview of what ESA's doing and, with its, uh, partners.

[28:03] Now, we know the definition of space safety today, it focuses on space debris, space weather, and planetary defense. So I'm going to add within that context, to that, the definition of space safety, talk about NASA's enduring purpose in the areas of discovery, exploration, and development.

[28:19] Uh, so starting with planetary debe , defense, the big area here. You know, whenever I see Lindley Johnson, um he's NASA's Planetary Defense Officer whenever I see him at headquarters, I always say, "You have the coolest job in the universe, and don't screw it up, man, [laughs] we're in big trouble."

[28:35] And on that front, uh, there's good news and bad news. Uh, so out of, uh, near Earth objects that are one kilometer or larger, um, whose impact could cause global effects, and global impacts, we think there are roughly only about 40 that have not been found. In other words, we've found roughly 96 percent of all these objects.

[28:52] Now, this is a really big deal and it's been ongoing for about 20 years, this project, since about 1998. Now, Congress, um, more recently, put into law in about 2005, that NASA should really be aiming to find about 90 percent of near Earth objects greater than 140 meters in size.

[29:09] Now, that's large enough to cause, US state scale devastation, um, from an impact. So far, only about 8,393 have been found. That's about one third of the total that we believe exist, about 25,000.

[29:23] Um, also presenting an even greater challenge is finding the near Earth objects that are around 50 meters in size. We're working on it. Um, we currently don't have a real mandate to work on it, uh, but these could result in city scale devan , devastation if they impact within 100 kilometers. Um, we estimate there are over about 200,000 objects at, of this size.

[29:44] Now, our Planetary Defense Coordination Office and the Science Mission Directorate, they're working hard to, to find undiscovered near Earth asteroids. So there are some asteroids out there that we're not aware of just yet.

[29:54] Um, we work closely with ESA, of course, performing, uh, orbit calculations, hazard assessment, impact mitigation, coordination, and avoidance, um, and we're both major participants, um, of the United Nations endorsed, International Asteroid Warning Network. Now, also, ESA is the current chair of the multilateral Space Mission Planning and Advisory Group. We're also leading members, and we strongly support its efforts and planning techniques and technologies, for dealing with the threat.

[30:22] On the mitigation and avoidance side, um, NASA's FY19 budget request included money for DART, which is a new mission, uh, the Double Asteroid Redirect mission, which we hope to launch in the summer of 2021. Um, the idea would be, it would encounter the moon of Didymos in October 2022, and that mission is currently in Phase C planning. Thank you.

[30:46] DART will demo the ability for space craft to deflect an asteroid as large as a hundred meters in size given at least about five years advance warning. ESA's Hera, a proposed mission for the upcoming ministerial to go from phase B into a full project would complement DART in many ways. For example, its data would be extremely useful to, to the overall effort.

[31:09] That launch projected sometime between 2023 and 2025. Essentially, it took the asteroid impact mission and rebooted it. Thanks to Johann Wörner's effort. We wish you well on that mission.

[31:21] Lastly, NASA is hosting the next International Planetary Defense Conference that will be here DC, April 29 to May 3rd next year. We invite anybody interested. It's the only international forum for the presentation and discussion of the latest developments and advances in protecting our planet from a really bad day.

[31:41] Finally, um, in terms of uh planetary defense I'd be remiss if I didn't mention OSIRIS REx. In light of the recent news with its rendezvous with Bennu, we should note that Bennu was actually a near Earth asteroid with a chance of 1 to 2,700 of impacting the Earth in the timeframe of 2175 to 2199. So we got, it's always out there still.

[32:05] The precise tracking of Bennu's orbit while OSIRIS REx is there will provide a much better understanding of the orbit perturbations caused by the Yarkovsky effect and this is the absorption and then re radiation of solar energy that can alter its direction and momentum. So we know where it might go.

[32:21] This can help us better understand how much of the orbit is affected by this effect over time and so we can determine whether or not it may be an impact risk. It's really an example of how our planetary science becomes applied science in the area of planetary defense.

[32:39] Now moving into space weather. You know it's an increasingly important area as most of our, a lot of our electronic communications rely on space based assets. Not to mention the potential damage to people now living and working in space outside of our protective atmosphere.

[32:54] A Carrington event named after an intense [inaudible] magnetic solar storm that occurred in 1859 would today have untold economic and human costs. At the time it caused global telegraph lines to spark perhaps even igniting paper uh, on the tables nearby and um, it really disrupted the Victorian Internet as it existed at the time.

[33:16] Now we work closely with ESA through their space situational awareness, awareness, office in Darmstadt. Um, our Heliophysics Division also has an active multilateral relationship with ESA and NOAA.

[33:27] Now currently, we're planning a satellite strategy. This includes the NOAA proposed space weather Follow 1 mission. Now this will be a replacement for the Discover mission that was launched in 2015.

[33:38] We're hoping that the uh, the upcoming FY20 budget passback is kind to NOAA. The proposed, this proposed mission would fly at L1 and launch in the 2023 to 2024 timeframe and ESA as we saw it is also proposing a complimentary mission to fly at L5.

[33:54] In addition to acquiring the satellite for NOAA, NASA has an interest in data from both missions and we're interested in flying instrument on each. Lastly, the three entities really work closely together on improving NOAA's and ESA's forecasting capabilities. Space weather preparedness is really a global, um, priority.

[34:13] Now space debris. From a public standpoint there's probably more awareness of debris and possibly more misunderstanding of debris um, due to the film "Gravity" as we saw some pop up our media. Uh, the open frontier of space is increasingly challenged with the growth of, growth of, space activity and the multiplicity of actors whether they be constellations and the, just a variety of actors.

[34:37] The International Space Station is already, on average, has to adjust its orbit several times each year to avoid on orbit debris. Now Space Command has stated that it's actually the number one asset that they track because it's our, it's our, home away from home. That's where our astronauts are based.

[34:56] Now debris has the potential to complicate our ability to develop, explore and discover. Especially when you consider that even solving some of the challenges like planetary defense or space weather, these are based on our ability to actually use satellites in orbit and get satellites up there, observation satellites, to safely launch them and operate them and so even that becomes more difficult.

[35:15] The National Space Council recently released Space Policy Directive 3 which aims to address this issue in a whole of government manner. Under the National Space Traffic Management Policy, NASA is leading an inter agency working group to update the US Orbital Debris Mitigation Standard Practices in coordination with the Department of Commerce and other US government entities.

[35:36] Now these practices have provided the global gold standard for how to avoid debris creation. And now with these new challenges it's time to update these practices.

[35:47] The standards will help the Department of Commerce to adjust and modify their licensing procedures to ensure that these best practices are followed on a regular basis. And NASA will be providing expertise um, and advice to the Commerce Department. Um, we continuously do conjunction analysis and modeling for our own missions as well as those of others, and we invest in the science and technology in this area um, to improve it and we share these with the rest of the government.

[36:12] Um, relative to ESA and international engagement, um, regarding the SPD 3 importantly the policy specifically acknowledges that international engagement on space situational awareness and space traffic management is important. Um, the Department of State will have the lead for the bilateral and multilateral engagement.

[36:29] Now in summary, the three inter , inter related issues of space safety really reflect the opportunity and challenges um, as I mentioned with regard to discovery, exploration and development. As humans continuously live and move beyond our home planet, we face a variety of challenges from a technical spit , standpoint. How are we going to get there?

[36:48] But increasingly from human health and environmental safety perspective. From debris and radiation, from space weather issues and e , events.

[36:58] Now starting next year, um, we hope to see a bit of a shift to increased suborbital and commercial crew activity. Um, we're hoping for a launch in uh, spring of next year for commercial crew.

[37:08] And um, this will mark a real shift from NASA's full involvement to a regime for private polits, pilots, from, a shift from NASA's involvement to a regime for private pilots and space flight participants focused on the risk to the public. In terms of preventa , preventative, medicine, occupational health, the long term health of astronauts, we want to share our history of knowledge. We've been conducting long term human spaceflight on this station for about 18 years and we think this we can really help out some of the new entra , actors that are entering this field.

[37:40] Now as they move further away from Earth we will also change our practice of returning crew if there's a significant medical issue. The mission to Mars for example, we're probably not going to come back, if you for example scratch your cornea or something like that.

[37:54] Such a move could potentially endanger the other crew and risk the entire mission and so distance will change our current operating program for spaceflight. We'll have to figure out how to develop solutions on the fly.

[38:06] And on this we're working diligently with our international partners including ESA of course, to better understand the risks of distance from Earth, ultra gravity fields, hostile space environment, radiation, um, and we work together to uh, figure out how to mitigate them as well. And as our human journey continues, we'll continue to learn, adapt and grow and to solve these issues together.

[38:27] So thank you. Thank you for your time. I appreciate it and um, I look forward to discussion.

[38:33] [applause]

Victoria Sampson: [38:33] Good afternoon everyone. I'm Victoria Sampson. I'm the moderator for today's panel and I'd like to now take this point to invite our speakers up.

[38:49] With that, since time is of the essence, you have, you should all have a copy of the bios of the speakers. I'd like to turn it over to our speakers. We'll just go down the line starting with Jim.

Jim Cooper: [39:01] Hi, good afternoon everybody. Thank you for being here today. My name is Jim Cooper. I'm the senior systems engineer on the SSA solutions team for Analytical Graphics Incorporated. I'm here to speak today about the challenges of space debris.

[39:14] We've already heard about it from our guest speakers. They've almost done my job for me. I'm tempted to say next, but I'll continue with my presentation and flesh out some of the things that they've said so far.

[39:23] Um, a little bit about me, just real quick. I'm a former U.S. Air Force officer, uh, spent time working in an operational crew on this mission area, and then spent significant time as a seeded contractor for the Air Force in the Pentagon doing SSA work along the lines of operations, uh, as well as policy and some international engagement work, including some Air Force to ESA work that was being done over, over the past several years. OK.

[39:45] All right. So as I said we're going to speak today about the challenges of space debris as it relates to space operations and an environmental hazard it poses to space operations. And what are we talking about?

[39:56] Well, we're talking about the congested space environment. I'm sure you've all heard over and over and over the three C's of US national space policy. You may be as tired as I am of hearing contested, congested and competitive, but realistically when you think about it, it still structures the framework of the discussion pretty well.

[40:12] So, what do we mean by the congested space environment? We're talking about the on orbit population that exists today and that's a mix of operational payloads as well as all the debris that's out there. Now the payloads themselves only make up a small percentage of everything that is up there, but that's obviously the stuff that we're concerned with.

[40:29] That's what this video is going to show you now. So this is the on orbit population as it exists in today's publicly releasable satellite catalog, that is released via USSTRATCOM through their combined space operation center of Bamberg Air Force Base, and you can kind of see that population growth that obviously starts with Sputnik back in 1957. We have the US and the USSR kind of being the prime guys there for a couple of years, and then other nations start to come in.

[40:55] As we get to the 2000s, of course, as Jan was saying, you start to see some other entries now coming in, the barriers to entry from a financial and technological standpoint drop. And as a result more and more countries, more and more commercial entities and consortiums start to jump into the game and that increases that rate of growth of the population.

[41:14] In addition, of course, and sorry just looped around. I mean, you've got two big catastrophic debris causing events that happened. 2007 we have the Chinese A Sat of course, and 2009 the Iridium Cosmos collision.

[41:26] One of those was purposeful. One of them was not. It was just a hazard of the environment but both of those created of course, thousands of pieces of debris. And that's where we stand today since it was somewhere depending on who you talk to and whether or not you include certain satellites in there roughly 18,000, 19,000 maybe 20,000 objects in space. The key to that is.

[41:44] [off mic comment]

Jim: [41:46] So that key to that is what we are. Thank you.

[41:49] [laughter]

Jim: [41:51] No, great segue. Key to that of course, is what we're actually tracking and maintaining for useful Space Situational Awareness today and that's what the next slide is going to drive at.

[41:59] So if we look at the LEO population, this is going to populate by size. So you're going to see on the left side of the chart some size brackets start to work their way in and you'll see the number of pieces that exist at those sizes.

[42:13] Now above a certain level, we track and we maintain space situational awareness. By we, I'm talking the global community of nations that does this work across the board.

[42:23] So we track and maintain down to an object size of roughly, depending on who you talk to, 20 centimeters, you know, give or take five centimeters in that range right there. We can argue about specific numbers but the point is we're somewhere in that area.

[42:37] Above that area there are roughly 20,000 objects. Below that area there are roughly hundreds of thousands conservatively, maybe over a million additional pieces that are not being reliably tracked and maintained today for space situational awareness.

[42:52] And if you can't do that, then you can't do the follow on downstream analytics for space flight safety and to take care of those issues that you need to take care of.

[43:00] So what we're showing here is that realistically we are today only tracking and therefore being able to monitor and assess for space flight safety purposes approximately 4 percent of the LEO population. The other 96 percent that's up there is essentially a known unknown.

[43:17] We know it's there from debris sampling campaigns. This isn't theoretical, we detect it, but it's an unqualified risk because we cannot maintain SSA with today's technology.

[43:30] Next slide down I want to just do the same sort of thing for GEO. You have the same sort of aspect here from GEO. The sizes now are a little bit different though, because you're further away obviously, out of the GEO belt. It's significantly further away than LEO.

[43:43] So that mean detectable threshold that I was talking about that you can maintain SSA for, is roughly at about the 50 centimeter give or take 10 centimeters range and above, and it's sort of similar to LEO. Where what we see here is that we're actively and reliably maintaining roughly 4 percent of the GEO crossing population and we are not accounting for from an SSA standpoint about 96 percent of that population.

[44:10] So this is all of that debris that we hear about. And in some cases this is even starting to be small satellites if they're not going up there with some sort of positive ID mechanism on them. We're having trouble with some of the CubeSats, and as you start talking about pico satellites and nano satellites, that almost is going to really resemble debris without some sort of positive identification system onboard.

[44:32] We will have the same problems with those that we have with all the debris. So again about four percent of the population.

[44:37] Where's all this coming from? Launch operations, on orbit operations, operational deployment of satellites, fragmentation events, so on and so forth and that's our big problem right there.

[44:49] To expand on that a little bit, actually European Space Agency has done an assessment recently in 2018 that says there have been approximately 500 debris causing events fragmentations, explosions, and collisions that are producing all of this problem. All right? And that's something that we have to think about and take care of as we move forward.

[45:08] NASA of course, was the first one to identify a collision between two operational satellites. A French satellite and a rocket body that occurred back in, I think it was, 1996 and that was the first time we saw that. Generated one new piece of debris.

[45:21] It was a low closing velocity. Think of you know, bump in the night as opposed to explosive, coming together at high closing velocity.

[45:29] Generated one new piece of debris. That's an example of a debris causing event.

[45:33] Then you go from there all the way up to a Chinese A Sat and an explosive and catastrophic collision between Iridium and Cosmos, destroying that satellite and creating thousands of new pieces of debris.

[45:45] What does that mean then for the operators? Well, the operators have to contend with this. If you are an operator and you're up there, you've got to think about the conjunction assessments that you're going to get from, uh, from, various services that exist today and you've got to contend with the risk and think through the risk of all of these other objects you can't see.

[46:04] What you're seeing right here then, is an uh, uh, occurrence that happened to the WorldView satellite. WorldView, uh, had what the J Spot term was by definition a "debris causing event." That's a euphemism for saying something else ran into it. And it created eight new pieces of debris.

[46:21] And you could see in there. I'll just start that again, real quick. That you, Josh? Thank you. [laughs]

[46:30] So what you see there, is you see the perturbation induced by that collision. You've got the green uh, orbital path. You have the explosive that, well, not the explosive but the collision event. Then you see the perturbation induced uh, as a result of that.

[46:41] Created eight new pieces of debris, degraded the operations. The satellite was recoverable so good for them but of course you have the other types of events where you can have a catastrophic explosive and, and destruction of uh, your satellite as a whole.

[46:54] Now this matters as an operator because you want to think through your problem set. Do I want to maneuver? I've got a conjunction assessment warning coming. Do I want to expend fuel? Do I want to lose life time?

[47:05] Do I want to maybe come off a particular operation that might have NASA security focus? Do I want to have to walk away from customer support on a, a particular thing to maneuver out of the way? And that's all part of your risk calculus for all of this stuff.

[47:18] [inaudible] I'm going to just advance through that one in the interest of time. So that's the situation today where we're tracking like I said about four percent of the catalog or, or I should say four percent of the on orbit population in LEO as well as GEO. That's, I think, a pretty bad picture.

[47:37] The situation here, unfortunately, is that it's going to get worse before it gets bette. And with that we're talking about the advent, of course, of the mega constellations that are coming, that are up, uh, up for proposal right now.

[47:48] This is the numbers chart. I got it. I'll take you through it in a second, but what you're looking at here is a volumetric statistical analysis that AGI did on the advent of mega constellations and what that means from a conjunction assessment standpoint.

[48:02] So I'm going to pick on, just for the sake of argument, just because I like them, SpaceX. Let's look at what happens with SpaceX when they bring up their 4,000 satellite mega constellation.

[48:14] That's the number when we did this assessment a little while ago it's more than that now. Uh, when they bring up their 4,000 satellites if we compare that against today's catalog inside the Gold Box.

[48:26] This is today's catalog objects that are 20 centimeters roughly and larger. And we run the statistical analysis on that SpaceX is going to have a potential collision over the next 10 years about a 50 percent chance in a 10 year period.

[48:41] So essentially one collision every 20 years with that mega constellation. If they set a threshold for a service and say, "I want to be alerted any time I see something coming within three kilometers of my satellite so I can think about it and decide what to do," they're going to receive almost 4 million warnings over 10 years."

[49:00] What do I do with that, right? My hair is on fire and I panic. That's what I do with that. OK. Not my hair because there's not, but some people's hair.

[49:07] [laughter]

Jim: [49:07] If I set a threshold of 1 kilometer for a collision avoidance maneuver then I need to do 440,000 collision avoidance maneuvers.

[49:16] Today's catalog let's take a minute, another step. Space Fence comes online and other assets and we're now tracking and maintaining single centimeter objects.

[49:24] I've got nine collisions over the next 10 years. I'm dealing with 72 million conjunction assessments and I'm probably doing eight million collision avoidance maneuvers. Again, hair on fire, panic.

[49:36] This becomes noise for an operator they can't deal with this and so they will let it blur into the background. They will understand that's a sort of a panic level I just have to accept and that's really the wrong solution, right? We need to do better as a global community. I think everybody recognizes that that's part of what this panel is all about.

[49:53] And that's, that's where we'll go from there. And so with that I'll just leave you with a picture of the com spot where we're generating SSA and we continue to assess and analyze these sorts of problems on a routine basis.

[50:04] And if anybody has any questions after this I look forward to that and I look forward to the rest of the comments from the rest of the panelists. And thank you for being here and listening.

[50:11] [applause]

Bill Murtagh: [50:20] Good afternoon everyone. Um, my name is Bill Murtagh. I'm the program coordinator at the Space Weather Prediction Center.

[50:26] My thanks to Secure World as always for all the great work you do, and our colleagues at ESA, always a pleasure to see you again. I'm going to touch on uh, space weather here for the next 7 to 10 minutes and give you an update.

[50:38] I'll touch first on the largely, some of the motivations behind the policy, uh, efforts that have been implemented introduced here in the United States to address the threat of space weather obviously on space systems but on technology in, in, whole. Space weather impacts I just wanted to touch on this for a second.

[50:59] You know, I used to talk about space weather impacts and show different types of impacts. And I realized that sometimes we get space weather outbreaks, and we don't see much in the way of impacts. And people say, "Well, gosh, that must not have been very important with impacts."

[51:13] I realized then that I actually had to share another kind of category of impacts and that is when space weather alerts and warnings and watches are, are issued people take action. That's an impact. It costs money.

[51:27] So I essentially divided this in two pieces here. On the left hand side is just that, is space operations, electric power grid, airlines, GPS navigation.

[51:35] Just, just a quick, just touching on some of the actions taken by industry. When we worked with the power grid, for example, I was talking to the, uh, PGM folks.

[51:44] They have a big footprint in the power supply in this country, from Illinois all the way to the East Coast. And every time we get a um, G3 on a scale of 1 to 5 geomagnetic storm 3 level warning cost them about a million dollars. Happens quite frequently over the course of the solar cycle, several times a year.

[52:01] I thought that was an awful lot of money. And the guy says, "Bill. We got one power outage in one city, we measured the outage, billions per hour."

[52:09] So they'll put it in perspective. They take that, uh, those measures. And so yeah, an impact for sure.

[52:15] On the right hand side, here, we see, even during this last c , solar cycle which has been, if you track space weather at all, it's been a very quiet solar cycle, hasn't been mu , not good for business. The, um, when things are not happening, but of course a , i , in the industry we appreciate when things are quiet, though. Even during solar minimum, though, we've had quite a few impacts that I've identified on, uh, just some of the headlines here on the right hand side, s , space weather.

[52:39] Um, just recognize, too, that it's, um, the impacts, you know, it's, so it's driven a lot of policy here across United States in the last several years and indeed our colleagues in Europe and elsewhere who are looking at this issue. So much of it is because we rely on technology for everything we do, today.

[52:56] And we're used to it, we know it's there. GPS is always there. The electric , electricity comes on when we hit that switch. What if it doesn't? What if we lose GPS for hours, or a few days, or should we lose power for hours or days, or in some cases someone suggested, weeks or even months? What would the consequence be? It would be very, very significant, needless to say.

[53:17] Another piece of, uh, space weather I like to highlight, um. Unlike most natural disasters, space weather is global in impact. A hurricane bearing down, a Category 5 hurricane bearing down on Miami, that's a big deal. But a space weather impact, especially an extreme one the Director General mentioned the 1859 Carrington Event should such an event occur today, the consequences would be global. Director General also talked about the importance of partnership.

[53:46] [off mic comment]

Bill: [53:46] [laughs] I will Jan, thanks.

[53:50] [off mic comment]

[53:50] [laughter]

Bill: [53:51] Very good. You mentioned, co operation is the enabler. Indeed it is, uh, and it must be, it must be done. Co operation across our nations to address this threat because of the global nature. No one nation alone can, can handle this.

[54:09] Impacts and space weather and satellites are a variety of, of different types of impacts. I don't want to go into any detail here but we certainly see surface charging that results in electrostatic discharges, both on the surface, and the internal organs, if you will, on the spacecraft also get impacted. We see single event upsets and a variety of different types of impacts.

[54:30] In the last couple, you'll see the increased spacecraft drag caused by thermal expansion that's one of the ones is getting a lot of attention in this category of space traffic management. When we do have all those satellites up there and the um, the de orbiting the maneuvers necessary space environment is a big, big player in a, assessing that the, the, uh, how that should work.

[54:52] Space Policy Directive 1 just to touch on this, we won't probably mention too much about the impact on manned spaceflight, but uh, our colleague Patrick from NASA's just talked about that. That it's coming back certainly in the United States next year and between government and NASA and commercial services, we're going to be sending people back and more frequently into space.

[55:13] And space radiation is a big concern. Radiation exposure in particular outside of Ear , Earth's magnetic field that's a different ballgame altogether.

[55:24] Our astronauts in the International Space Station a couple hundred miles high, lots of protection they do get exposure. They do take action when we have big radiation storms from the Sun. There's hardened parts of the Space Station that they'll reside in during those events. But once we get back to going to the moon and onto Mars, we're outside that cocoon of Earth's magnetic field.

[55:45] It's a whole different ball game, alerts and warnings will be critical. So in response, across the board federal agencies in this country have been working on this threat, whether it be the DHS within DHS FEMA, the Department of Transportation, and so on.

[56:03] But it was recognized in 2014 that we needed some kind of a cohesive national strategy to address space weather. Consequently, I actually was led the effort t , to deploy to the White House for two years.

[56:14] In October 2015 we released the National Strategy and Action Plan. A plan to have a cohesive strategy across all the federal departments and agencies to address this latest threat of space weather. Goal six of the six goals of course, was a focus on international as I mentioned global threat global response.

[56:35] October 2016 just one year later, we realized we needed even more than just a strategy and action plan. We wanted to put the hammer down on this and we needed either legislation or we needed a directive coming from the executive office and the, President Obama signed an Executive Order 13744 on space weather, mandating many of the activities contained within the strategy and action plan.

[56:59] And just an update, last week we're in the White House again with a revision of the National Space Weather strategy. And a lot of it, we focus on this administration's priority based on SPD1 and SPD3 Space Policy Directive 1 and 3 on space traffic management and space exploration.

[57:16] Congress is also reacting here. And, uh, even as we speak over the last week or so, the efforts within the House to, to essentially consolidate the S , Senate bill that was introduced back in, in 20', May of 2017 with the House bill in July of 2018 and we expect there's a lo ...

[57:37] I talked to folks recently and there's high confidence that indeed legislation will be passed on the Hill to address again the, the threat of space weather. Um, just wanted to touch quickly on a couple of other things. NOAA satellite programs.

[57:52] I mentioned a policy, but of course we need the critical observations necessary to support a viable space weather operations alert warning services. And this is some of the, some of the tremendous achievements essentially over the last five years or so.

[58:07] Goals 16 and 17 we continue since 1974 our goal suite of satellites. People generally understand the value of the goals for terrestrial weather, but the key space weather instruments are also onboard those satellites. With that long term commitment to continue our space weather measurements on goals, we launched Discovery in 2016 that's our L1 Lagrange point.

[58:32] Again, Jan mentioned the importance of that as a sentinel, a buoy out in space alerting us t , to incoming coronal mass ejection. He also mentioned that the Futrelle 1, we're going to continue our work

on, uh, L1 and by 2024 we expect to fly, uh, follow on at the next space, the next, uh, solar wind instrument suite and, uh, a chronograph as well.

[58:55] And of course, Cosmic 2 coming up next year where we get the critical occultation data that's really going to help us assess and understand and better predict changes in the ionosphere very important for the GPS user community.

[59:09] So I'll just leave with this last piece with our colleagues here from, um, from ESA. A coronal mass ejection put it into motion there. A billion tons of plasma gas and magnetic field shot off into space. This is the key thing above all that motivated action at the White House and across government circles is the potential impact of a coronal mass ejection when it hits Earth's magnetic field.

[59:33] The geomagnetic storm, the induced currents in the ground into our systems this is the biggie. We've got a spacecraft at L1. I just mentioned the Discovery spacecraft. NASA, our good colleagues have flown the A spacecraft for the longest time providing a tremendous, uh, L1 information.

[59:51] Now we've got our own NOAA discover. And as Jan said, what if we had a spacecraft out there on the left looking in on the side, so we could dissect essentially. Look at that CME coming towards us and measure it as it's moving out towards the Earth.

[60:05] Having that different, those different dimensions would make such a difference, we believe, in our ability to predict this. So we are working closely with our colleagues in, in, in Europe to s . We'll make that commitment to continue our L1 measurements and if those folks can pull it off and get that L5 up there, it will be a huge, huge step forward. Thank you.

[60:31] [applause]

Diane Howard: [60:36] Well, hello. First I'd like to thank Secure World and also ESA for inviting my participation today. I'm going to talk about, I'm going to focus on some of the challenges and I'm going to flesh out a few things that were addressed from my colleagues on the panel and also by the two key notes.

[60:51] Um, so I'm going to, I'm going to speak from the perspective of the private sector and oversight of the private sector and some of the challenges with regard to safety. So we have safety getting to space as well as safety in space. So, I will first talk a little bit about, uh, Space Policy Directive 2 which address streamlining regulations.

[61:13] And some of the regulations that it discusses streamlining are those launch and re entry regulations. So I want to talk about that a little bit because that was something that was long coming.

[61:23] It was invited by industry. And the safety reviews for the launch licenses is pre , is primarily where we provide the oversight for our private sector and make sure that they're performing their activities to get to space responsibly.

[61:40] One of the biggest challenges that we have here in the U.S. is that we don't have on orbit authority for most activities in space. We do have on orbit authority to the FCC for telecommunication satellites.

[61:52] And so that's something that has also surfaced a bit in the last, uh, I would say last month. So Space Policy Directive number uh, 3 which has also been addressed and talks about space traffic management, also talks about, uh, end of life.

[62:09] And talks about NASA taking the lead on this advisory group which our colleague [inaudible] . And um, looking to see whether or not the, the uh, standards that are currently in place that uh, we're using as part of our safety licenses, rather our safety reviews for our launch licenses, but that NASA also uses and that are used and relied upon uh, around the world whether or not they really have the same effect, efficacy, and, and um, if there were adequate for the kinds of things that we're talking about doing now like mega constellations and very small satellites.

[62:45] So a challenge also here in the U.S. is that, an NPRM was issued by the FCC at the very, believe very end of October, very beginning of November. And in this FCC NPRM, a lot of the end of life issues are addressed.

[63:01] And, and it does address the fact that SPD 3 had assigned the lead to NASA, but it acknowledges this uh, sort of jump in jurisdiction. But it says that it's necessary for the FCC to go forward with this, because we don't know how long it's gonna take for us to get anywhere with, with agreement on new standards.

[63:23] And in the interim that the, the work that they have been doing on, on the end of life issues for the on orbit authority that they have, that this should go forward. And so, I will let anybody in here, in, in this meeting room who has an interest know that the public comment period is open on this NPRM and I invite you to look at, look at it. It's on the Internet. The public comment period is over on the 9th of December so it's right around the corner and that would be something to look at.

[63:53] For challenges, um, I discuss the fact that they're, you know we have safety in space, not just getting to space. So we are addressing in the US the safety to getting to space, [inaudible] for those out in February.

[64:08] But we also have this issue about on on, on orbit authority. So SPD 3 assigns that authority to the Office of Space Commerce which is in the Department of Commerce.

[64:20] That said, there are some pieces of legislation that are currently, they haven't made it past committee, and they have different um, the House bill is very much aligned with SPD 3 and the Senate bill is not as closely aligned [inaudible] , so it is unlikely that this will be resolved.

[64:48] That said, we still have a lot of very, very interesting and productive efforts that are going on in the private sector like HEI. In academia, there's work being done in a number of different universities. I'm most familiar with the work at University of Texas at Austin and, and my university, Embry Riddle.

[65:09] And, and there's uh, uh, a great deal of interest in how to bring together, all of the different kinds of data so that wherever the on orbit jurisdiction ends up and however it's handled, whether it's handled [inaudible] contemplates, or whether it's something, some hybrid or something else.

[65:30] Um, there, there's still work that's being done. Grassroots work that's being done, so I can tell you a little bit about the kind of research that I see.

[65:38] Uh, [inaudible] , all of these issues, getting to space and then once we're in orbit, uh, debris and, and also dealing with satellite to satellite and conjunction analysis and, um, supplementing and using as a springboard the information that we get from J Spot and going beyond.

[65:59] And I can tell you that this year the, the abstracts that we are currently reviewing are pretty remarkable in, in the breadth and the scope. So that's, that's something that I can tell you is going on. And one of the things that is addressed in the House bill one of the things that I like so very much kinda follows on to something that Jan said [inaudible] invited in, in the end of your talk.

[66:24] And, and I believe I kinda heard you [inaudible] that is this idea of uh, aggregating information, aggregating good data and bringing it in from all, all providers. Be they governmental, be they industry, uh, be they academia. And, and bringing in this, uh, the information.

[66:44] And not just bringing in it and collecting it, but also coming up with some very good ways to vet the information, to verify the information, and to make sure that the information is um, a format that is usable by multiple users and [inaudible] . So, I can tell you that I'm seeing a lot of those kinds of uh, research projects that are coming up.

[67:04] So [inaudible] have challenges. We are undergoing massive NPRMs here in, in the US. A lot of regulatory [inaudible] is, I believe also an NPRM [inaudible] that's just about to come out.

[67:24] And um, these rule makings are going to address some of the challenges that have been [inaudible] . That, that's very hopeful.

[67:33] Beyond that, some of the less settled issues, like who's going to handle, ultimately handle some of the [inaudible] on that, the governance issues, the standards, and the traffic management issues.

[67:47] That remains to be seen, but there is a lot of work that's being done on the ground. And I, uh, again will en , encourage [inaudible] some of the public comment opportunities that all of this rulemaking provide.

[68:06] [applause]

Charity Weeden: [68:06] Good afternoon, everyone. Um, my name is Charity Weeden.

[68:11] Thank you to Secure World and to ESA for uh, putting on this, this timely panel today. Uh, Just one thing. O , one of my past lifetimes was as a Royal Canadian Air Force officer and I had the pleasure to work with Jim in that capacity, and puts a fine point on the importance of international cooperation for space safety.

[68:30] Um, reminder so, Astroscale. I'm here representing Astroscale.

[68:36] It's developing a commercial space debris removal service, to secure long term space fate, space flight safety. They have a global footprint. By the way, we have offices and employees in the Singapore, Japan, the UK and presence here in the US with yours truly.

[68:54] An in space demonstration is scheduled for early 2020. It's aptly named end of life service by Astroscale demo or ELSA d for short. The concept is to have satellites attach a lightweight docking plate with a ferromagnetic substance uh, coating on it. And if that satellite is, goes defunct prematurely, uh, Astroscale would send up a servicer to attached to it magnetically and help de orbit it.

[69:22] It is especially important right now as we talk about the mega constellations and at their altitudes which they're planning to be in a thousand kilometers and up. Uh, if there is predicted 5 to t , 10 percent, uh, infant mortality as they call it, of satellites in that, uh, orbital area.

[69:41] Then this could mean there are dozens, if not hundreds of dead satellites, uh, stuck in that orbit. Therefore, we think this is a necessity, uh, to have this type of service be available to the commercial community.

[69:55] Which brings me to the major point I want to make for this conversation that commercial entities have a significant role to play in assuring space flight safety. This is an obvious statement for this, uh, community. But when you think of the major dialogs and efforts in this air , arena, IDC COUPOS LTS, even within government policy development on the matter, a commercial space input can sometimes be secondary or nonexistent.

[70:23] So let's look at some metrics for the commercial space community to set the tone of the significance volume, simple volume lots of satellites. I'm not just talking about in the next five to ten years, but today.

[70:37] I looked at the UCS, uh, uh, data this morning. The number of commercial satellites in space today as compared to civil military and academic all combined is approaching 50 percent. A 1,000 satellite constellation means commercial community owns and operates the clear majority of active spacecraft in orbit. We are at a tipping point.

[71:00] Economy, according to SIA, State of the Satellite Industry report, $270 billion in revenues are generated in 2017 for the commercial space community compared to $80 billion for government space budgets. This does not even include downstream economies that rely on commercial space. I'm not even mentioning jobs here that OECD report from 2013, a little dated, uh, shows that 900,000 jobs worldwide, uh, include, uh, are space related.

[71:34] Investment. According to Bryce's space, uh, investment report, $18.4 billion has been provided to startup communities since 2000. These investments, especially those past five years, these past five years are resulting not only in hardware in space, but ensuing ground systems, downstream applications. A case in point is the SSO A launch that delivered tech demos for emerging space companies.

[72:05] So, now that given that the commercial space sector is a critical voice in providing end benefits to businesses, the public, and makes up a significant amount of activity in space, I'd like to discuss why space safety is fundamental for this thriving industry. Simply put, this is about the bottom line. Investors are weighing potential returns. Insurers are looking at the risks. The threat of more difficulty in obtaining licenses, which delays launches and therefore business.

[72:35] There's obviously a clear business imperative to being a responsible actor and to demand that your neighbors are as well. This is the type of culture that is established with most operators, that needs to grow towards all operators.

[72:52] What is responsible commercial space operations? $80,000 question. Uh, so, details of what exactly that is emerging through best practices, dialog, standards and legacy, uh, internal operational practices.

[73:11] I just want to put "one size does not fit all" here. There are a range of technologies, range of orbits and a range of experience to consider.

[73:19] Some of the major themes, however, have to do with making satellites detectable, ensuring cyber security, understanding more about the environment and more precise SSA, and sharing information among operators. And thinking more thoroughly about post mission disposal techniques. This needs to be done in concert with the government and other private entities that are accessing space in collaboration in the development of best practices and standards.

[73:49] In, in addition to a business imperative for operators to be safe in space, there is also a new market that is emerging to support responsible space operations. And this is reinforcing the culture shift that I just mentioned.

[74:04] Developing a new space market is rare, but this is one that will improve the operating environment and encourages continued growth in the industry. I'm talking about commercial SSA services, on orbit servicing, in active debris removal and end of life services, like that Astroscale is involved in.

[74:24] So how can the industry have an impact and a strong voice in space safety? One, know before you go. Understand the policy, regulatory environment, legislation, ongoing dialog amongst the community for space safety.

[74:41] This cannot be left as an afterthought. It needs to be baked into your business.

[74:46] Two, participate amongst the industry with your colleagues. Astroscale's [inaudible] confers, and other best practice, uh, developments.

[74:57] It can be, it doesn't have to be formal. It can be informal. Come talk to me. Let's discuss what it means to be a safe space operator. We can have this dialog in the industry.

[75:07] Three, make sure your voice is heard in the government and in, uh, international bodies. Interact with them. As Diane mentioned, there are many opportunities now and coming up for you to make, uh, your voice heard in the NPRM cycles.

[75:23] And then finally, walk the walk. Think about all phases of flight, including post mission. Ask yourself. Why would I de orbit within a 25 year period when I could de orbit in a 25 day period?

[75:38] For government entities, we ask that you acknowledge commercial contributions. Support technology development for commercial space safety and include, uh, commercial voices in any and all domestic and intergovernmental dialog.

[75:53] Those are a few of my thoughts. I look forward to having a good, robust dialog after. Thank you.

[75:58] [applause]

Todd Harrison: [76:05] Hi, I'm, uh, Todd Harrison. I'm with the Center for Strategic and International Studies here, and I want to thank, uh, ESA and Secure World Foundation for inviting me to be part of this panel discussion.

[76:17] Uh, you know, my part of the, the contribution here I think is to bring in national security perspective, uh, to space safety and what's going on in the space environment. Uh, so, on the one hand, national security space systems, uh, face many of the same challenges as commercial and civil space systems, uh, from the space environment.

[76:38] You know, as our national security space systems not just for the US but for our allies, our partners, and others around the world are becoming, uh, more important, more integral to our war fighting capabilities here on Earth. Uh, the value, uh, that we place in them, uh, means that we cannot afford, uh, to have disruptions in their service.

[76:58] Uh, and if you just think for a minute of the, the space debris problem. Uh, if you accelerate that to a point where you've got to be constantly maneuvering your satellites, uh, to avoid debris, you are going to shorten the life, uh, of your space systems.

[77:14] Uh, and for national security space systems there are some of the most expensive, uh, satellites that we have on orbit. Uh, and you know, that comes as, as a big cost to our militaries, uh, to other countries' militaries.

[77:28] Of course, national security users of space can also contribute to making the space environment worse. Uh, as was mentioned earlier, the 2007, uh, Chinese kinetic ASAT test.

[77:38] Uh, you know, the world community I think agrees that that was done in an irresponsible manner. Produced a lot of long, lasting debris that is still creating challenges for us today. If there is more of that, uh, we're only going to see the problem grow exponentially.

[77:56] Uh, and you know, there are also, uh, issues with a potential co orbital ASAT weapons, uh, that could also produce debris. Although not necessarily with the same energy and the same, uh, number of pieces of breakup of debris, but nevertheless that can create challenges as well.

[78:14] And it's not just the use of these systems in conflict, of course that would be a terrible outcome for all involved. But the testing of these systems to prove their operational viability, to prove their effectiveness will also leave a permanent scar in the space environment, or could leave a permanent scar.

[78:35] Uh, and you know, related to that, a challenge that we have in national security space is that we lack basic norms of operations for space. Uh, and when you lack norms that can cause you, uh, to view just about anything that's going on in space as being abnormal because you don't have a norm to compare it to.

[78:57] Uh, and so that can heighten uncertainty. It could heighten suspicions, uh, uh, among nations, and ultimately lead to miscalculation or misunderstanding of what is going on.

[79:08] You can imagine a scenario where you know, you may be tracking objects, you aren't sure what they are. They're maneuvering or appear to be maneuvering close to one of your high value space systems and then something happens.

[79:23] Something goes out on your satellite. Uh, you know, maybe it's an electrical disruption, a processor goes off line or memory gets corrupted, uh, and it can lead you to think that, hey, this was a deliberate hostile activity. It may have actually been a combination of circumstances in space weather.

[79:42] Uh, but if you don't have good awareness of this, if you, if you do not understand the space environment fully, and if the environment has gotten so polluted, uh, with pieces of debris, uh, it's only going to increase the odds of this happening at some point. Uh, you know, and, and ultimately, this is a problem for us because our ability to deter attacks against our space systems has been called into question.

[80:09] Uh, and that leads us to, to fear that an attack may be coming. Uh, an attack through means that we do not necessarily fully understand. And in the space environment, it is remote and it is hard to tell exactly what is going on.

[80:26] Uh, and so this risk of miscalculation, misunderstanding can ultimately lead to strategic instability, uh, here on Earth. Because, you know, the United States, and it's not just us, it's Russia as well, it's China to a certain extent, we rely on our space systems, uh, to support our nuclear forces.

[80:46] Uh, we rely on them for missile warning, we rely on them for command and control. We rely on them for understanding the battle space, uh, and what is going on Earth.

[80:56] And if these systems, uh, if someone believes that they are under attack or an attack is imminent, uh, it could, it could be viewed as a prelude, uh, to a, a, a nuclear first strike or otherwise. And so that strategic instability is a real problem. Uh, and that is one of the main national security risks that I see, uh, for what's going on in the space environment.

[81:20] So, I look at this from a national security perspective, and you know, what's, what can we do about it? I think the most important thing we can do, uh, is invest in better space situational awareness capabilities. Uh, the more that we can know what's going on, the more we can reduce the risk of misunderstanding a miscalculation.

[81:40] Uh, if we can see better, if we can understand the environment better, uh, you know, understanding the space weather better, understanding the RF environment in space better. The more, uh, eyes and ears that we have on orbit that contribute to our, our total understanding of the environment and what is going on, that will allow us to better decipher between, you know, what is the random event? What is the weather event?

[82:05] What is just an environment, uh, that was not necessarily, you know, hostile, not directed at us and what was actually a hostile act? Uh, and if you can't differentiate be between those two, it puts you in a really bad position strategically.

[82:19] Um, so I'll stop there. And uh, yes, we can open it up for questions.

[82:24] [applause]