Summit for Space Sustainability
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Panel 2: Megaconstellations – The Train Has Left the Station. Now What?

Spotlight Talk Speaker: Timiebi Aganaba, Assistant Professor, School for the Future of Innovation in Society, Arizona State University (introduced by Krystal Azelton)

Moderator: **Chris Johnson**, SWF Space Law Advisor

Panelists:

- Tim Farrar, President, TMF Associates
- Hugh Lewis, Professor of Astronautics, University of Southampton, UK
- Randy Segal, Partner, Hogan Lovells LLP
- Andy Williams, External Relations Officer, European Southern Observatory (ESO)

Krystal: Hi, everybody. Welcome back to the 3rd Annual Summit for Space Sustainability. We are now going to turn to our next panel, "Megaconstellations -- The Train Has Left the Station. Now What?"

To get that train rolling, I will hear a spotlight talk from Timiebi Aganaba, the assistant professor in the School for the Future of Innovation in Society at Arizona State University. She'll share some thoughts on the potential consequences and opportunities for megaconstellations.

Timiebi Aganaba: According to the United Nations Office for Outer Space Affairs, over 11,000 space objects have been launched and recorded in their online index, but this number is set to increase significantly as private companies and governments intend to launch tens of thousands of satellites into low-Earth orbit, known as megaconstellations.

This trend is driven by the reduced cost of hardware and launch and the increased demand for low-latency/high-broadband Internet to underserved locations. While US companies like Amazon, Canada's Telesat, and UK's OneWeb proposed megaconstellation satellites in the order of the low thousands, US-based SpaceX alone has announced plans to launch 42,000 satellites as part of its Starlink Project.

If this happens, SpaceX will be responsible for a fivefold increase in the number of satellites launched by all of humanity. Of those 42,000, they plan to have 11,926 launched in orbit by 2027.

Also importantly, as the European Commission is currently studying the feasibility of a European-owned space-based communication system, and the Chinese government has created a

company dedicated to creating and operating a 13,000-satellite broadband constellation, the soft power political and security element is also present much as we see with global navigation.

This means that some actors may enter this vertical even if the business case is not evident. One of the big questions is, does servicing this increased demand warrant all the increased risks in low-Earth orbit, the atmosphere, and on Earth?

COVID-19 showed us the extent of the digital divide problem. Those connected were able to maintain business or find new opportunities and continue their education. Those who were not – whether in rural areas, indigenous communities, or in developing countries, found themselves further marginalized. This leads some to question whether there is a right to be connected.

While low-Earth orbit is not the only way to be connected, proponents argue that it is cheaper and faster, and this serves to bring many of the world's population into the 21st century. But should this goal be met *at all costs*?

The astronomy community were one of the first communities to raise the alarm in a significant way about the risk posed to their activities by the brightness of satellite constellations. Namely, that the constellations cause streaks, diffused background light, and cause radio noise that may prevent access to the sky.

Essentially, two proposed rights are pushing against each other – the right to be connected versus the right to a dark and quiet sky. The space industry argues that there is no hierarchy to space activities, and everyone is free to explore space subject only to the Outer Space Treaty.

But as Article I of the Outer Space Treaty highlights, the freedom of outer space is subject to the condition that space be explored and used for the benefit and in the interest of all countries. In this case, what is “benefit”, and who gets to decide? We must promote dialogue to ensure that space activities - are and continue to be - beneficial for all of humanity.

Untracked debris is also a big risk as this could lead to potentially dangerous in-orbit collisions on a regular basis. Other less known risks include that satellite re-entries could deposit more aluminum into Earth's atmosphere, and accumulative impact of thousands of rocket stages on the oceans environment could be significant should the stages contain hazardous materials.

But should we still be concerned as some operators seem to be listening? According to Telesat CEO, operators are following best practices regarding how to deal with debris and in designing satellites to minimize debris, protect the space environment, and are launching into the lowest orbit so the troubled satellites can decay quickly.

In response to astronomy concerns, SpaceX has been meeting with the astronomy community regularly and innovating around a coating called dark set and a sunshade to address the brightness of satellites.

The issue is, can we rely on the good faith of these actors? Some argue that what they're doing does not go far enough.

For instance, in recent times, the news has reported controversy involving close approaches between a Starlink satellite and OneWeb satellites and the European Space Agency where coordination did not work well. With no space traffic management system or global space situational awareness capability, we may hear more of these issues.

What do we do next? The International Astronomical Union has now decided to take the issue of light pollution to the United Nations Committee on the Peaceful Uses of Outer Space, requesting that they protect the night's darkness for the sake of advancements in astronomy; but astronomers are just one stakeholder. Mechanisms will be needed to balance interest and encourage coordination.

Boley and Byers argue in the recent edition of *Nature* journal that to address the myriad of concerns that will affect all communities, international cooperation is urgently needed, along with a regulatory system that takes into account the effects of thousands of satellites, including actions to improve space situational awareness, improve communication between operators, and internationally adopted right-of-way rules.

Chris Johnson: Alright, excellent. Good morning, everyone. Good afternoon or time appropriate greeting for where you're at. My name is Chris Johnson. I'm the Space Law Advisor at the Secure World Foundation.

This panel now deals with megaconstellations. The first panel focused on terrestrial matters. We're now leaving the terrestrial domain, and we're looking at the space domain. I really think that Timie's introduction and her framing video puts out a lot of these issues that are at play, the fact that we have these competing legitimate uses.

We have the use of the space domain for megaconstellations and all the benefits that they offer, but we have these other legitimate uses of the space domain – like optical astronomy – and the fact that there's these real challenges for space traffic management and space situational awareness.

Luckily, we do have a panel with us who can get into some of these issues. I don't think we're going to find any perfect solutions, but at least we're going to be able to highlight and elucidate some of these issues.

Joining me on my panel first is Tim Farrar. Tim is the president of Telecom Media and Finance Associates, his own consulting firm based in Menlo Park, California, which specializes in the technical and financial analysis of wireless and satellite ventures. Tim has over 25 years of consulting experience across the telecom and satellite industries, having worked for leading technical and strategy consultants in both the US and the UK. Mr. Farrar, thank you for joining us this morning.

Next, we have Professor Hugh Lewis. He was the head of Astronautics Research Group at the University of Southampton in the UK, and has been working in the fields of space debris and space sustainability for over 20 years. He is a member of the UK Space Agency delegation to the Inter-Agency Space Debris Coordination Committee (the IADC) and is the chair of their

Working Group II on Modeling. He's also currently a member of the Royal Astronomical Society subgroup, assessing the impacts of satellite megaconstellations on optical astronomy. Professor Lewis, thank you for joining us as well.

Next, we have Randy Segal. Randy is a partner at the law firm Hogan Lovells, and has over 18 years of in-house general counsel experience. Her work focuses on satellite, wireless drone, and technology transactions. Randy's transactional and advisory experience has brought her throughout North and South America, Europe, Asia and the Middle East, and on the most complex of international programs and legal issues. Randy, thank you so much for joining us.

Last but not least is Andy Williams. Mr. Williams is the external relations officer of the European Southern Observatory, where he supports strategic relations with current and future member states, the European Union, and international organizations such as the UN. Prior to joining the European Southern Observatory, he worked as a senior policy advisor for NATO and as a physicist for the UK Government.

First, I'd like to speak with Mr. Farrar. Tim, in that spotlight talk that we all just heard, Timie introduced this idea that there are tens of thousands of satellites that are predicted, that are likely to be launched, and enter into operation in the space domain. Largely from the US, Canada, Europe, and likely as well, China, do these predictions seem to make sense to you from an economics and business standpoint – maybe if you have some perspectives on that? Is there really a market to support some of these plans? So, Tim, over to you.

Tim Farrar: Thanks, Chris. Just in terms of bit of personal history, 25 years ago, I worked on a lot of the big LEO projects back then, ICO, Globalstar, Iridium, Teledesic for many years, and then saw the aftermath of that with the many, many years of bankruptcy and litigation over the collapse of a lot of those projects. That colors my perspective that, you know while it's very true to say there *could be* tens of thousands of satellites launched. If you go back 25 years, the predictions that people were making back then was everyone's cell phone would have a satellite capability, and there will be tens or even hundreds of billions of dollars spent on satellite broadband within a decade.

It just didn't happen, because the economics didn't work out. Now, here we are 20 years later, and sadly, I'd say a lot of people have forgotten the lessons of the 1990s. These things come around 10 years later or 20 years later when everyone's retired and forgotten about it.

We still face a lot of the same challenges. Yes, the technology is advanced, but the technology is advanced in terrestrial, even faster than it has in satellite over the last few decades. And, it's still really unclear.

I think what I'm concerned about is that we see lots of statements about how awful everything will be with 40,000 satellites from SpaceX or 100,000 satellites from all the different companies combined, because people look at what is filed with the ITU, what is filed with the FCC.

People make filings to stake out a position because they can only step back from it later. They can't move forward and add even more satellites at a later date and keep the same priorities that they had.

So, I guess my question for people like Hugh will be: Ok, great, it may be terrible with 40,000 satellites, but if we take some real rational point of view that maybe there's only 4,000 or 5,000 satellites that get launched – and even that requires a lot of money to be invested over the next 5 to 10 years, which may or may not be available – who knows what's going to happen to the financial markets – but 'is the situation a complete crisis and disaster with, let's say, 4,000 or 5,000? Or, is it really only with 40,000 or 50,000 satellites that that becomes a problem?'

So, that's what I like to hear from some of the other panelists is: let's take what we view as rational, let's say, SpaceX is saying already 'we can't launch the V-band satellites because their aren't any terminals and propagation is terrible and everything else. So, let's focus on what people's concrete near-term plans are. If that's a terrible situation, then please tell us because that's going to need a lot more urgent action than worrying about something that hopefully will never happen to the tune of 40,000 or 50,000 satellites.

Chris: I like that, thank you. Those are good questions for Hugh. Hugh, the predictions right now, like he said, people are really worried about 40,000-50,000 satellites. What if it's only a fifth of that? Before you answer that, though, I really want to know...

I mean, the challenges for megaconstellations that they pose to SSA, space traffic management, and the debris issue, whether it's at this higher number that is possible or possibly a lower level, what do megaconstellations mean for space traffic management and our awareness of the domain?

Hugh Lewis: Thanks very much, Chris. That's a good question. I'm going to thank Tim later for setting me up with, actually, quite a tricky question to answer.

A lot depends on the attitude that these operators are going to take into the space environment. We've run computer simulations, which can show a big impact on the space environment, if the operator is perhaps not as advanced in the stewardship of the environment.

All we can see for the same number of satellites with a very similar type of setup actually are a rather benign situation. We're beholden to the attitudes and the approaches that these operators take, both in terms of the impact on the orbital debris environment but also in terms of space traffic management.

It's not necessarily been a great start. If we look at the particular encounters that SpaceX, for example, have had with the Starlink constellation, quite public events have enabled us to get some insight into the challenges. It hasn't been great to be perfectly honest.

A lot needs to change going into the future to ensure that we don't run into even worse problems with respect to the space traffic management concerns and the orbital debris concerns as well.

I think that there are some very good and very positive signs coming from the operators in terms of how they intend to operate. It's just a matter of making sure that they actually stick to those kinds of things.

Chris: I'll ask a more pointed question. How worried are you on some of these issues now? How worried would you be if they only deployed and put into operation a fifth or a third of what they predict and what they aspire to? How worried would you be if they roll out everything and get everything working on orbit, a true global megaconstellation? What does it really look like?

Hugh: To be honest, I'm worried, really, no matter the number of satellites that we're talking about because we're into unprecedented territory, and it's being driven not by governments that tend to move in very slow fashion. It's being driven by companies and companies that aim to disrupt the market, and they're doing the same thing in their space environment.

If you take, for example, this fail fast, fail often mantra, that is often associated with companies like SpaceX (potentially others as well). It's about short-term-ism. It's not necessarily focused on the long-term issues. It's a philosophy that sets up the idea that there's no problem that you can't overcome, and you just iterate through those problems.

It works fantastically well for things like failures of components on rockets or on spacecraft, but when you're hit with societal issues and challenges, it doesn't work well at all. Orbital debris is one of those issues, same thing with the astronomy issues as well.

Those companies aren't set up. They're a little bit naïve in that sense that they don't necessarily have the foresight to be able to solve those problems in advance. They deliver almost test satellites into orbit, and then wait for a problem to occur, and then fix them quickly and fly a new satellite.

That doesn't work. That leads me to worry quite a lot about the impact that these constellations can have on the environment.

Chris: We run into that quite often where new users of the space domain think that they're the only or the first users of the space domain. It just is not necessarily so. Thank you for that. We might have to come back to you.

I want to now go to Randy and talk a little bit about the regulatory environment, the approval environment. Randy, what does it look like? What does the regulatory environment look like for megaconstellations?

You can use whatever term you want, if you want to call it global systems or global constellations. What does that type of approval process look like, and where are we at on the regulatory front? Unless you can't hear us, in which case, we'll have to come back...Oh, go ahead.

Randy Segal: Chris, thank you. First, I'm so glad that Tim...

Chris: We hear you. Go ahead. I just wanted to start off by saying, Tim, thank you for having the memory that I do, going back to the '90s in Teledesic and all those megaconstellations then. I

will tell you that this is different. Back in the '90s, when this happened, we always thought that they must know what they're doing.

These smart companies must know what they're doing led by smart money, and there has to be something there. It was too early for its times. I will tell you a lot of things that are happening now are very different, different in feeling than they were in the '90s. I genuinely believe that this is real. It doesn't matter to me, whether it's 40,000 or whether it's 30,000 or 20,000.

I think that SpaceLink and Piper are real. I think the Chinese will be going up with their megaconstellations. We have so many other 100 to 1,000 constellations that are in existence as well. The issues on light pollution, the issues on, the environmental issues with aluminum particles from smallsat launches, and the issues of orbital debris are real with launching every...

[audio glitch]

Chris: It seems she might get caught up a little bit. Randy, we'll come back to you. I want to quickly go to Andy at ESO to talk about the challenges for ground-based astronomy, optical astronomy. What does it look like now? What are your predictions for the near term?

Honestly, this issue developed rapidly over the last couple years. It's not like it took us by surprise, but it came up on us fast. If you could tell us a little bit about that, educate us on the effects on your profession.

Andy Williams: Sure. I just want to start off by saying ‘thanks for the invite’ and for considering astronomy as one of the stakeholders now in this issue of megaconstellations. I just want to reflect on Tim's question, which he put to us.

Just note that astronomy observatories have lifetimes of 30 or more years, so we have to plan long term, and we can only act on the basis of formal government plans, such as the ITU filings. Even though it might be the case that not all the filings are realistic, these are the things that we have to base our assumptions on, on the planning for the long term.

If we consider the main projects in development, we can expect several 1,000 satellites overhead at any one time. Particularly just before sunrise and just after sunset, most of them will be illuminated by the sun and potentially detectable by a telescope.

If you live in a city, you might not notice anything unless you know exactly where to look, but if you go to a dark sky area, you will see tens or even hundreds of moving objects in the sky. This is a change to this beautiful landscape, which is one of the few natural wonders that is accessible to every single person on the planet. I really believe that the international community has to consider this.

From the perspective of astronomical science – while the impacts is depending on the interaction between the telescope and the constellation system – the basic impacts depend on the number of satellites, the size of the telescope, and the orbital altitude of the satellites, which is a very important factor.

Overall, the impacts range from quite minor to some of the large, narrow-field telescopes are looking at a very small patch of the sky, to very severe for those facilities that need to do their science at twilight when there's more visible satellites, and the wide-field telescopes that are looking at a large portion of the sky.

The largest of these at the moment is the Vera Rubin Observatory. They're facing many percentage of images *ruined*, and almost every single image having a satellite trail in the early hours of the night, so they're facing substantial extra costs to achieve their defined science goals.

You're right that this issue really took us by surprise. Satellites have always been a problem. I think, the root of the issue here is that none of our environmental laws directly have addressed the visual appearance or even the general sustainability of the space environment, and the optical spectrum is not managed in any way. There's no regulation to compel space actors to take action or for governments to set a level playing field of rules.

If we consider the radio sides, there are thousands of objects that are now transmitting. Radio observatories were able to observe outside the slim portion of the spectrum that's protected by finding the local radio quiet zone, which offers great protection.

The issue is that these radio quiet zones can't offer any protection from space-based transmissions. We're going to have this problem of just much more background noise from these thousands of new antennas in the sky and the electronic noise that's coming from the satellites.

We've been working with the community. We've been working with the industry. I can go into some more of those aspects later, if you'd like.

Chris: Certainly. Listen, we have a lot of students that are also attending. If you can recommend any kind of backgrounder, or document, or something that summarizes many of these issues, please feel free to share it.

My question also is...Actually, hold on. You said satellites are always a problem. Satellites have always been a problem. Is that true that even if it was just a few satellites, even that caused problems for astronomy?

Andy: For radio astronomers, they know now that there's big arc across the sky, which is the Geostationary belt where there are satellites in there. Essentially, in certain frequencies, they just have to avoid this area.

Satellites have been a problem from the optical side. Already, the Hubble Space Telescope is getting some percentage of its frames affected by streaks. In general, the impact scales with a number of satellites. Just in the past two years, we've seen a few thousands new additional objects added.

The problem is increasing rapidly. If you look at the projections, we could see 100,000 new objects looking at the ITU filings, and then this is getting into some serious impacts.

Chris: Are you coordinating with the folks like the Space Situational Awareness folks and the Space Debris folks. Because – I don't want to say grievances – but you both have issues that are talking about the same actors, the same users. You both have problems with the megaconstellation operators. Is there some type of coordination already happening?

Andy: The astronomy community has formed several national working groups. Also, we have a group that's under the auspices of the International Astronomical Union. And, as part of these groups, we've invited experts in Space Situational Awareness. Hugh is a member of the UK Royal Astronomical Society group that's looking at this.

Of course, this is important because part of the solution to the issue for astronomy, part of the solution is about finding ways to compel industry to share data on the trajectories of the satellite predictions for the future. Of course, this is something that will also help the space situational awareness question.

I would say this collaboration is just starting to emerge, but I think that a direction where we need to go in the future is to really work more closely together between these two communities.

Chris: Ok. At the top of our panel, we had a poll for folks to weigh in on some of the topics. If we can bring up the results of that poll, and we might have to revisit the poll near the end of the panel. Let's see. We asked the attendees, "Are the predictions about megaconstellations numbering in the tens of thousands of operational satellites in the next decade overestimating, about right, or underestimating?"

It seems they might be agreeing with Tim, that almost half say that they're overestimating. All right, it makes sense that, if you say you're going to launch, or you aspire to launch tens of thousands, and 40,000, 50,000 satellites, you might be overestimating.

Let's see: 34 percent says they're about right. I think that I wanted to highlight that, but even if it's not exactly what we're going to meet, it seems like we're still going to have some of these issues, a lot of these issues.

I think it's important to not frame it as 'one side versus the other', or binary 'operators versus optical astronomers', or 'operators versus those who are worried about space debris and SSA'. Does that make sense? Is there way to not have this be totally a clash of legitimate uses? Anyone that wants to weigh in on that. How do we not make it a clash?

I see Randy has joined us back again. Good. Randy.

Randy: How do we not make it a clash?

Chris: Go ahead: [laughs]

Randy: Well, my internet is working. This is why we need to make a constellation, so there's better internet as well. It's not just commercial versus other, the astronomers, and the orbital debris.

We have to work on this together. We have to work, because the internet...You see what happened in countries and with people who didn't have internet during the COVID crisis and everything else. This is something that really the World does need, in terms of having the satellite connectivity.

The challenge is how to do it at the same time that the orbital debris in particular doesn't cause issues for destroying, like the plastic in the oceans, and everything else. This is a global issue. How do we have coordination with megaconstellations being launched by folks like China if we're not communicating with them?

These are global issues, although the US is ahead of all the other countries in terms of launches that it's flagging. This is a global problem that we have. While a treaty, a United Nations type of process is not going to keep up with as we've learned over the years, it's not going to keep up with the rapidity of, that's going on.

With advances, there's got to be some kind of a forum compromise that allows for remedies and doing the best thing as a global citizen because space is for everybody. If we do it wrong, we're going to create a problem that's going to be the gift that gives for eternity.

Chris: Responses? Go ahead, Hugh.

Hugh: Thanks. Randy's absolutely right. Thanks very much, Randy. I'm glad to have you back. One of the biggest issues that we have is that these megaconstellations are regulated at a national level. There is very little coordination that takes place between the regulators.

You have a decision that's taken place in the US about a megaconstellation there, and we can have a decision that's made in the UK or elsewhere in the world. There's no sense that the combined effect of those two constellations going into orbit is being considered by either of those regulators.

We *have* that knowledge. We have the capability to make those assessments, but there isn't any forum where that can be addressed and where the regulatory aspects can actually be sorted out.

Chris: Andy, European Southern Observatory is an observer at COPUOS, and they just wrapped up...Well, actually, it was a while ago, they did the scientific and technical subcommittee. Can you give us, were these discussions held at the international level at COPUOS, and any results, or what's going to happen next?

Andy: I think the issue here that has been touched on, the astronomy community is engaging with the industry, and the industry are engaging with us. This is much appreciated, and some companies have made substantial changes to the designs of their satellites, like SpaceX.

We're having this situation of bilateral agreements, nondisclosure agreements between single observatories and companies. “OK, we can do this with 5, but can we do it with 10? What are the other countries going to do?”

It's just something that becomes unsustainable. I think what we need is a global approach to this. That's why the IAU works on this and made the first approach to UN COPUOS, as you said, at the Science and Technical Subcommittee.

We made a set of recommendations that, amongst other things, it set some basic requirements to mitigate damage to astronomy, to protect the night sky, to encourage governments to regulate on the matter, and to create a norm of cooperation and consultation with the astronomy community over space activities.

In the discussion that happened at COPUOS, I was really pleased to see that many countries recognized the value of astronomy and the concerns that we have, but the problem in this system, it's so complex.

It's linked to many other very, very difficult issues such as the allocation of slots for low-Earth orbit or the ideas such as a carrying capacity for low-Earth orbit and all the problems with space sustainability in general.

There is a sense that no country could really take a firm stake and say, “Right, we're going to adopt these recommendations.” It was what we were expecting, which was basically ‘carry on working, carry on studying the issue, and report back next year’. That's a first step, but in this year, another 1,000 or 2,000 satellites are going to be launched.

Randy: Can I just jump in here to what Andy said? One of the regulatory requirements, not for the geospatial satellites (remote sensing), but for the connected broadband satellites, is you have to get landing rights in countries.

Even though, for example, the United States is the one that flags the constellations from the US or the UK for OneWeb, etc., you still need landing rights to go into countries. I think that that is a potential strategic negotiating leverage point, other than just being good corporate citizens with the constellations to try to achieve all the goals that we have.

Let's put China aside because that's its own creature *vis-à-vis* the United States. As to everything else and everyone else getting landing rights is critical to a lot of the businesses and could be a basis to begin a dialog with the countries.

Tim: Let's be blunt here. A lot of this business is going to be based on defense applications. Iridium got rescued from bankruptcy by the DoD because it felt it was a system that was going to be critical to the US to preserve.

It would not be in the least surprising if a very large proportion of the revenue from some of these companies came from defense applications. In that sense, how do you really – as a national country that's concerned about its own technological advantage in space – how do you concede to something like the UN body that they should control your strategic priorities?

Randy: Tim, let's just go with your hypothesis that the DOD, defense communities in the US is driving some significant portion of revenue for the constellations, not just Iridium, as it had done

but some of the others. They need the deployment in other countries as well for their missions. They do not control the deployment in those other countries.

Each of the other countries still has their own respective potential – I'm saying *potential* – gatekeepers to accomplish environmental or other orbital debris goals if theirs differs from that of the United States.

Tim: True. Of course, the regulations applied to a Host Forces Agreement are not necessarily the same as the regulations applied for selling terminals to consumers in the country. I completely agree that there will be limitations. For the commercial part of the business, if you can't get access to a wide variety of countries, you're going to have a big problem generating a business plan.

That may mean that some of these operators fought back even further and harder on defense applications where the leverage points a very different for getting access into a particular country if there's a war, a disaster, or some other crisis that requires access.

Hugh: But I think, Tim, we can't forget the operators themselves, and certainly from an orbital debris point of view, that they're probably best placed to police themselves because if they cause debris issues in the orbits that they're in, then of course, that's going to harm their own business.

In many senses, the orbital debris issue is also perhaps more easily managed, thanks to the need to operate in a clean way. I think that the astronomy issue is outside of that because there is no incentive there for the operators other than the concerns being raised by the astronomy community to behave in a different way.

Tim: Absolutely. Iridium got most of what it wanted against radio astronomy back 20 years ago. They have made some compromises. They've made some improvements in subsequent designs, but in the end, the objective of the radio astronomer is to keep them out of the band that was very close to a key observing band. It didn't really happen in the way that people wanted it to happen.

It's a huge problem. I would just take issue with Randy's statement. She said that 20 years ago, we thought people knew what they were doing. It proved that they didn't, and now is different. My view is: it's not different. No one knows what they're doing. No one knows what the market is. SpaceX was saying five years ago that they'd have $30 billion of annual revenue from this by 2025. No, sorry, it's not happening. It's just not. No one knows what the market is. No one knows what the economics are.

We're in an environment where endless money is being thrown at space. It's a huge investment theme. People are thrilled. People see these billionaires who they think must know what they're doing. We're seeing all these SPAC companies which range from very ambitious to probably not going to work, and take your pick, but people are still prepared to fund them.

It's a very difficult situation. How will long the money last? How long people prepared to go on with that when they see the real results? Iridium, everyone was gung-ho about this in 1998. Nine months later, it's in bankruptcy because there weren't any customers. Maybe, today is different in

the sense that people are more forgiving for maybe a year or two, but in the end, the ‘proof's in the pudding’.

We're going to have to see how many customers these people actually serve, how much revenue they generate, and whether it's sustainable. I will just add one point about Iridium. The big difference between Iridium and Globalstar was that the satellites for Iridium lasted 20 years, which allowed them to build up a business [and] pay for a second-generation system.

Globalstar satellites lasted seven or eight years and put the company behind the eightball the whole time. It's always been a massive struggle for them. One of the key questions in my mind for all these systems is how long their satellites last, because if they only last five years, then it's all very well to say, “Oh, good. They'll all be upgraded.”

The economics get massively, massively worse for any system. If you can only make money and have to ramp up over a period of three, four, five years, people, you have to replace it.

Chris: That's true. We do see that that idea of “go fast and break things”. Randy, you have something to comment?

Randy: I was going to say, Tim, two things. One is the economics of the systems are enormously different than with Iridium and Globalstar, and that whole wave of bankruptcies happened in terms of what it costs to build these satellites are often being built just next to the engineer's desk, maybe just literally or figuratively. I don't know.

The launchers are enormously different in cost than they were back in the ‘Olden Days’. I will say to you that I do agree with you, certainly, on the wave. Space has become sexy, and the number of companies that have been SPAC-ed in pre-revenue stages is astonishing to me in terms of the successful outcome.

Time will tell how many of them are still standing in five years or have gone through bankruptcy. A lot of the companies we saw in bankruptcy, then second-owners, were successful in building the business. In five years, Tim, I predict, we'll talk again, you and I.

Chris: This is ‘on the record’, by the way.

Randy: It's on the record. I predict that it will not be the same as the '90s. Of course, there will be plenty of companies that have consolidated or gone away because this is not sustainable. In all the numbers, there are in each different segment that exists. There will be winners, but there will be winners that don't go through bankruptcy. I think there will be. Five years, Tim, we'll touch base.

Tim: I'll take the bet. It's ironic. The people who've been here a long time and its… I find one most ironic comments when Eutelsat said it was investing in OneWeb or the other. They basically said the best thing about OneWeb is it's already had its bankruptcy.

Randy: [laughs]

Tim: That's indicative of the history here.

Chris: Folks, for those who are watching and attending, we do have the possibility to submit questions through Mentimeter. We can put up the code for you to quickly find, type that in at Mentimeter. We already have a few questions that I want to get to.

Honestly easy, the first question is dealing with this term that we use, megaconstellations. Why must we use the term megaconstellations? They opine "It is an imprecise term. It hints that the more satellites that are in a constellation, the more risk the constellation poses. It clouds that fact." Any reactions to that and maybe solutions? Professor Lewis?

Hugh: Thanks, Chris. It's a good question. My interactions with various companies, they dislike the term quite considerably. If you take the literal meaning, then of course, it is not accurate. We use 'mega' for lots of things that are big. It's slang for things that are big.

In this case, the constellations that we're talking about are bigger than the typical space systems that we've used to. It perhaps isn't quite as bad as you might think. Across the community, we tend to try and use the term "large constellation" instead.

Tim: There's a history there. Back in the '90s, we had little LEOs which were the data that only small satellites like Orbcomm. We had big LEOs, which was Iridium and Globalstar. Teledesic was referred to as 'mega-LEO', to distinguish it from Iridium and Globalstar and to be indicative, perhaps, of broadband communication as well.

It's just got picked up from there in a way. Even though it shouldn't, it refers to the broadband constellation rather than anything else.

Chris: There's the technically precise approach to finding the right term, and then there's the effect it's going to have. If you call them global constellations or megaconstellations, it sets an image in some people's minds. I don't think we have a real solution to it though.

This next question details, 'what is the current thinking on the best ways for constellation operators to exchange enough information to safely coordinate their constellations', so general SSA, and how is that going to work in the future, especially between private and state-owned systems? Anyone would like to take a swing at that? That's a tough one.

Tim: Let me throw in just a little bit of thinking about… there's an issue of when you have thousands of satellites, you've got to have a high level of automation. That's what SpaceX has talked about for its constellation that everything happens by remote control.

You do run into a problem with two systems. If they're both automated, then how do they react to one another? They might both move in the same direction, so they both don't take themselves out of the path. They both think they're diverging. They divert the same way, and they're still on a collision path.

There's two aspects of it. One is you have to have rules between operators in terms of saying, “If you're doing this automated, then we don't move.” But the second stage of that is, “If you're doing automated, we have to trust your system actually works.”

So I think one of the rules here has to be that regulators have to impose more disclosure obligations so that people know and can verify that the other company is doing the right thing, is going to move this way, maybe they say they always move to the left or something, but you have to have validation.

There has to be disclosure. It can't all be kept confidential. You have to have confidence that what the other side is doing makes sense and what you're doing is not making the problem worse rather than better.

Randy: I agree entirely with Tim, but I also don't know that this can be fully accomplished with the mounting number of satellites out there including failed satellites and other orbital debris without having some kind of centralized or coordinated equivalent of an air traffic controller, someone that's either an intergovernmental body or some country that takes the lead.

The operators have to disclose their information too, the same way for aircraft you have to say where you are with your aircraft, so that you can coordinate and try to avoid a collision. I don't know that it can be done exclusively between the operators – there's just too many of them, and there's too many differences in the degree of self-supervision.

Tim: I would almost categorize into two things. One is monitoring all the stuff that stably and can't be maneuvered. Then the operator knows it's not moving, and they have to move themselves. There's the case of two satellites that are potentially controllable.

What do the two operators have to do? The cases that were cited in the introductory talk about ESA, and Starlink, and OneWeb were all satellites that are under control. The issue there was the simple fact of like, “Well, who's going to move? Is it you or me?”

Not necessarily knowing what Starlink was doing. When it was sent, it all be automated, well, who knows how that automation works? Which way does it move? Do you trust it? All of these sorts of aspects?"

I completely agree with Randy that for the debris side, the stuff that isn't moving, there needs to be considerable monitoring. Lots of good information about that, responsibility put on to the operators, but then monitoring what the operators are doing, understanding the regulators have a responsibility to understand that their procedures are ‘best practice’ and how they're reacting relative to one another...

[audio glitch]

Chris: It looks like he froze for a second. I think that really leads into this next question about what happens if a constellation operator goes bankrupt, so please display that next question.

What happens when a constellation operator goes bankrupt with a partially deployed constellation? Is there contingency plans? They say that it seems unlikely a buyer would emerge.

Randy, how would a national regulator even consider that? Are they thinking about something like that, and what do you think would happen?

Randy: First, most of the systems have spectrum and/or have IT priority of some sort, which are both valuable commodities.

I believe that even if it's a giveaway of a system, that someone would assume in bankruptcy – and most bankruptcy laws in most countries are pretty much the same – would assume the liability and to deorbit or to do whatever else it is for the constellations and/or use the constellations for another purpose, particularly, if they have spectrum and the like.

A partially deployed system can still be used for certain purposes and/or a buyer could pivot and come up with a new business model for the spectrum, for the spectrum, for the system. There was speculation at some point with OneWeb that even if they didn't continue with that constellation, the spectrum alone was very valuable to someone.

Hugh: It's also worth pointing out that during the bankruptcy, the satellites paused in the orbit raising (for example). They didn't continue in the way that they could have done because, of course, if no buyer emerged, then the safest thing to do for the environment would have been to deorbit those satellites. It's easier to do that, less risky, from the lower altitude.

The liability issue is a really good one because, obviously, the responsibility is going to fall to the launching states to take the necessary action at the cost, of course. It's good to see that, actually, there was that pause with OneWeb in terms of their operations.

Chris: I have a directed question. Many people could weigh in. This one about prospects for reforming the regulatory system, someone asks, “Randy, what are the prospects of reforming the regulatory regime to include things like light pollution?”

When you apply for a frequency when you apply for a launch license, it doesn't ask on there, “Are you affecting ground-based astronomy?” It just isn't on there. Should it be? If you were a regulator, how would you take some of these equities into consideration?

Randy: The regulatory regime has been undergoing, in the last five years, significant evolution to try to actually be quicker on its feet. Some of the regulators, and the ITU process, and the FCC was a very slow one, and wasn't addressed to a lot of the commercialization of space.

There was a real move in the last five years to try to accelerate and expedite regulatory approvals and to make it easier to go to space. I think that there are, though, a number of issues as the technology continues to evolve with large constellations, issues that no one thought of, really, the light pollution when they were building it, etc.

The FCC in particular has pushed back recently and said satellites are not governed by the Environmental Protection Act. There's an ongoing case in DC. That's by competitive satellite companies challenging the Starlink constellation.

I think that the regulators are going to need also to come together on some of these issues, because these LEO constellations and large constellations, especially the ones that don't need landing rights in other countries, the other countries don't have a say on what those constellations are going to look like, and how it affects their territory.

I don't think it should just be the regulator of the existing country that has a say, but then that wreaks havoc. If you start imposing all these other requirements like light pollution, NEPA, everything else, then the speed that we've gained over the last five years to support commercialization and the space industry will become halted.

It's a real tradeoff of how do we take into consideration these issues, and at the same time, how do we support the commercialization of space?

Chris: That's the dilemma. That's the paradox. Anyone else want to weigh in? Should the regulators ask that question? Should it be on their application? Andy?

Andy: At some point in the distant past, the FCC didn't consider space debris guidelines. Then at some point, they did. Of course, part of the logic behind its inclusion was that orbital debris affects the asset that is under regulator directly. It would be trivial for a regulator to add in this extra step that they have to do.

But I think as Randy said, it comes with a cost which has been imposed on that particular system. This is where, as Randy said, we need the regulators to come together. It would be possible and that from a certain time, all the major spacefaring countries agree to include a certain set of minimum standards against light pollution.

I will also point out that there's a law, one single law, that regulates light pollution from space, and this is the US law against space advertising, which came in via – I think it was direct from the Congress – it didn't go through the regulatory process, so it is possible.

Chris: Tim, if we add these requirements, these questions already to the prospects for megaconstellation, how does that change your prognosis and your predictions for the future? Would it slow down the growth of megaconstellation?

Tim: One of the issues that has to be considered is the degree to which it makes people flee to regulatory jurisdictions which don't have these rules. It's already been a big issue in launch about to what degree do you have to post bonds? To what degree do you have to have insurance against casualties if something falls out of space and hits/lands on someone's head?

Any satellite operator has to then take the decision of like, “Well, do I go to this country where it has these impositions?” Maybe, if that country is going to be supportive of me and help to lobby to get myself in the right place, regulatory-wise, in terms of market access, then maybe that's a trade-off worth making.

On the other hand, you're going to have more fly-by-night operators going to countries which don't impose these rules, and that doesn't help anyone.

Chris: Thank you for that. Listen, last question. I have to ask it because it was upvoted so much, and we have to face this conception, this idea. How do you avoid the concern that megaconstellations are essentially appropriating certain orbits? The sole occupant of a particular orbit – that's a concern. Anyone want to weigh in?

Tim: I would say it's not just the orbits. Clearly, when there's a loss at a particular altitude, it gets very difficult for anyone else to launch there. I worry at least as much about appropriating spectrum, and we have this dilemma between the US rules and the ITU rules: who has priority? Who has to share?

Elon Musk said: He doesn't respect the ITU, like he doesn't respect the Securities and Exchange Commission. When people say that sort of thing, how do you resolve it? I don't know.

Chris: Listen, last thoughts as we wrap it up, the idea that we have all these competing uses, I think we presented a whole buffet of issues and questions. Maybe we didn't get to any particular answers, though, but any last thoughts? Please go ahead.

Hugh: From my side, if I was in the position of an operator, I'd actually be quite frustrated. They've demonstrated perhaps my reliability of the systems. They've innovated towards smaller satellites that are more capable. They've addressed all the IADC concerns on an individual satellite basis.

I'd be quite frustrated at the moment. They've pushed forward quite effectively. Yet, they're seeing all these concerns being raised still, that the goalposts are shifting all the time. That's an ongoing process that they're going to have to deal with.

Chris: Fair enough. Thank you for that. I want to thank all my panelists for offering their wisdom and their expertise in this last hour.

We're now going to move directly into the next session, the next panel, on "Activating Active Debris Removal."

Thank you to everyone, and we go directly into our spotlight talk from Darren McKnight.

[pause]