HOUSE OF LORDS

UK Engagement with Space Committee

Uncorrected oral evidence

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Watch the meeting

Members present: Baroness Ashton of Upholland (The Chair); Baroness Bonham-Carter of Yarnbury; Baroness Donaghy; Lord Lansley; Baroness Mobarik; Lord Shamash; Viscount Stansgate; Baroness Stowell of Beeston; Lord Tarassenko.

Evidence Session No. 13 Heard in Public Questions 120 – 126

Witnesses

I: Dr Imogen Napper, Visiting Research Fellow, University of Plymouth; Professor Hugh Lewis, Professor of Astronautics, University of Southampton; Professor Don Pollacco, Professor of Astrophysics, University of Warwick.

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Examination of witnesses

Dr Imogen Napper, Professor Hugh Lewis and Professor Don Pollacco.

Q120 **The Chair:** Welcome everyone to this next public session of the inquiry into the UK's engagement with space. I am delighted that we have with us three real experts: Professor Hugh Lewis from the University of Southampton where he is professor of astronautics, Dr Imogen Napper, who is a visiting research fellow at the University of Plymouth, but who is joining us live from Nairobi where she is going to be for the next two years—thank you so much for joining us long-distance—and Professor Don Pollacco, who is the director of the Centre for Space Domain Awareness at the University of Warwick. Professor Pollacco, you are very familiar as I was Chancellor of the University of Warwick for eight years until only a few months ago; it is lovely to see you. Thank you all very much for being here.

The subject that we are going to focus on today is orbital debris, which has been seen as one of the big challenges that we face. As the number of satellites and the number of launches increase, so too does the creation of debris and the potential, at least, for what could be described as an in-orbit collision.

The UK is looking to position itself as a leader in sustainable space and debris mitigation; we will use this session so that members of the committee and anyone watching will have the opportunity to learn from your experience and knowledge. I am going to begin by asking Lord Shamash to ask the first question.

Lord Shamash: Thank you again for coming, and thank you Imogen Napper for being online. Most of us have not contemplated the problem of space debris, but as the committee has been sitting for some time, we now realise that it is a substantive problem; there are 11,000 or 12,000 satellites up there, maybe more. Could you provide us with an overview of the extent of the space debris problem, and how pressing it is? As a sub-question, do you have any reflections on the likelihood of a Kessler event?

Professor Hugh Lewis: Thank you very much for the question, and for the kind invitation to be here. Space debris has been an issue for decades. The first warning came from a US scientist known as Donald Kessler and his colleagues at NASA, who introduced the world to the problem of space debris back in 1978 with a paper. It has been nearly 50 years since that first paper and a lot has changed in that time.

You are absolutely right in terms of the number of satellites. The number of active satellites in orbit at the moment is about 11,500, which is a huge change from just 10 years ago; at that time, we were looking at just under 2,000 active satellites. That big change is due to how we are using space and the commercialisation of space, which is very important. Back in 1978 there were probably just a few thousand objects in orbit, but now we are unfortunately looking at more than 40,000 that are

tracked and in the public catalogue, and probably more than 50,000 that we could track. Trackable objects typically would be a bit larger than a tennis ball, but there are many objects in orbit that are much larger than that as well, and the speeds at which they travel are enormous. Even something small is going to carry a lot of energy and break something up, so that is the risk.

In terms of whether it is pressing, the speed of change over the last 10 years has really drawn attention to the topic. Operators are now having to manoeuvre at unprecedented rates. Some operators are manoeuvring tens of thousands of times a year—maybe 100,000 times a year—to avoid debris and to avoid those collisions.

Lord Shamash: When you say manoeuvring, do you mean altering the position of a satellite? For instance as if a tennis ball is coming towards it, and you are saying, "My goodness, we have to move this".

Professor Hugh Lewis: That is exactly right. It raises legitimate questions about whether we can sustain that type of situation, both with awareness—our understanding of the environment and the objects—and the capabilities of the satellites themselves.

In terms of taking action, it is very important that we act now. The population is expected to grow exponentially, doubling at quite a rate; as always with exponential growth, you want to act as soon as you possibly can.

Professor Don Pollacco: You would think that, as space is infinite, there would be plenty of room for 50,000 objects. In fact, Hugh has underestimated the problem. There are probably near to 1 million objects that contain enough energy to damage spacecraft. Most of those are not tracked.

The other thing that is really important is that, even in this infinite space, if you do not know the position of things accurately you end up thinking there are going to be collisions. Most of the movements of spacecraft—using consumables which shorten their lifetimes—are actually unnecessary. But it is a game of poker: do you want to risk it or not? If you do not move and you get hit, that is £100 million down the drain.

The real issue, however, is that we just do not know where the debris is with sufficient accuracy. How many cars are on the earth? A few billion. They are not crashing all the time because we know where they are. But in space, a lot of this debris is actually untracked, and even with the stuff that we do track, we do not know the positions with great accuracy.

Dr Imogen Napper: I come at this from a slightly different angle; I am the odd one out in that I am a marine scientist, but I have studied plastic pollution and waste management over many years.

During Covid—when we were all going slightly crazy and had additional time—I was watching one of my favourite films: "WALL-E". It is about a robot that is left on earth to try to clean it up because the humans have

made such a mess, and there is a part in the film where the humans escaping earth have to crash through a sea of satellites. I went slightly crazy thinking that this seemed so similar to what we had in the oceans. There is so much we can learn in terms of the successes we have had there but also the failures.

The pattern with plastic pollution and satellite debris is incredibly similar. I appreciate that there are vast differences between the ocean and earth's orbit, but it is still about the generation of waste. Synthetic plastic was only invented in the last 100 years, and it has really benefited our lives. The clothes I am wearing are plastic; I have a plastic pen. The whole room I am looking at, probably similar to you, is plastic. But the problem is that we never designed the waste management and end of life for the amount of plastic we have created.

That is exactly what I want to bring to this discussion today; it is a similar issue. We are focusing so much on the benefits that satellites can bring, which are vast, but we are not focusing on the end of life. We just keep trying to put more and more up there. We are focusing too much on the removal of the debris rather than just turning off the tap and stopping the debris from happening in the first place.

The Chair: That is absolutely fascinating.

Lord Shamash: I was going to carry on with a question about the Kessler effect. That is where, as I understand it—but please correct me if I am wrong—a satellite disintegrates and then the spread of the shrapnel, if I can call it that, causes damage among all the other satellites. Have I got that right?

Professor Hugh Lewis: Yes, more or less. I tend to take a slightly different view to the mainstream media with respect to Kessler. The portrayal in the film "Gravity" is how many people see the Kessler syndrome. The reality is somewhat different.

Back in that 1978 paper I mentioned, Don Kessler articulated very clearly what the problem is: the number of objects in orbit and their size. If we increase the number of objects and make them bigger, there is a greater chance that they will hit each other.

The Kessler syndrome is essentially like rain falling on saturated ground: there is nowhere for that rain to go, so you end up with frequent flash floods. We see the same thing in orbit: the more debris we create and the more objects we put into that environment, the more likely it is that we will see collisions. Those collisions can feed others because the shrapnel, as you say, goes on and hits other satellites. But we always come back to the fundamental cause, which is that we keep throwing objects into orbit and we are for ever increasing that number of objects.

Q121 **Baroness Donaghy:** We will be going into specific policy solutions later, but it would be interesting to hear some high-level reflections on how to address this issue. What interventions are necessary to prevent the

creation of more debris?

Professor Hugh Lewis: Dr Napper mentioned planning waste management and end of life. Although that is not sufficient, what we do with the satellites once we have finished with them is very important. One of the biggest things that we can do is to manage that end of life and do it well. The only other recourse we have at the moment is probably to remove the derelict objects that exist in orbit, but that is technically very demanding and very costly.

Our current approach to removing debris at the end of life—typically for satellites that are low in altitude—is to lower their altitude even further so that they burn up in the atmosphere. We are now understanding that this process is potentially harmful to the atmosphere, to things such as the ozone layer, and potentially has climate change effects as well. So we have a problem in terms of what to do with satellites at end of life. That was our most effective debris mitigation measure, but now we have to do something different.

Professor Don Pollacco: One of the issues is that, if you have enough resource, it seems relatively straightforward to build a constellation of satellites. There is no regulation—or not enough regulation—stopping people from launching them. Right now there could be several hundred thousand spacecraft on the books by the end of this decade. That is just unimaginable. Not only is it unimaginable in terms of how we look after space, because it needs to be looked after, but from the ground, what are we doing to the sky? Youngsters go out and look at constellations; for a few hours after sunset and before sunrise, the sky will be ablaze with things moving. It is already like that to some extent, and it is going to be more like that.

It sounds like a silly warning, but the problem is that money is talking. Money is producing these constellations of satellites, and no one is trying to preserve the sky for people to look at.

I am 63, so I feel the rush to do things, and I feel the need to go out and do things myself, but it is not clear to me how this can be controlled. There are good reasons to do it, but you have to understand what the cost really is.

The Chair: Dr Napper may have some views from the ocean side of things.

Dr Imogen Napper: What my colleague was saying was funny because I was camping in Kenya a couple of weekends ago and we saw a Starlink satellite trail going across the sky; there were maybe 10 to 15 satellites being sent into earth's orbit. That is certainly something I do not remember when I was younger. It is quite perplexing how quickly that has changed.

On the same day, there was a news article in Kenya warning people in a certain area about falling space debris. A few months before that, some space debris had actually fallen in a village in Kenya. It is real and it is

happening. We can learn from the mistakes we have had with the oceans, and the systems we are putting in place to try to fix them.

If I were to look at a high-level decision, I would look at extended producer responsibility. We focus too much on cleaning up our mess when the damage is done, but if a company or a Government or whoever have designed a satellite, we need to make sure it is environmental right from when it is being made, including where they are collecting the sources. That initial stage has to be environmental, all the way to how it is being launched, how it is being used in space, and then eventually to how that satellite is going to be removed so that it does not create debris.

If we had made these decisions 20 or 30 years ago for the ocean in terms of plastic pollution, we would be in a much better space than we are now.

Baroness Donaghy: Does that mean there is a liability at the production stage and the company or the Government have to say that they will be responsible for its disposal? Is that what you are saying?

Dr Imogen Napper: Absolutely. If you are designing satellites you are going to make a lot of money; it is not in the thousands, it is in the millions, maybe billions. Because of that you have the capacity and the time to think about how this product is environmental across its whole life cycle. Let us not just think about how we are going to clean up the mess at the end. Let us think about the whole life cycle and really put it into the hands of whoever is making that satellite, so we are not finger pointing at who is to blame.

Lord Shamash: I have a question for you all about the disposal of satellites. As I understand it, a satellite has a fuel load of some sort to make it work. Is it possible to make it mandatory that when a satellite comes to the end of its useful life—when, say, it has 10% of its fuel load—that fuel load could just send it up into outer space, never to be seen again? Is that possible? I gather that is something that has been considered.

Another thing is that I saw a picture in our paperwork of a satellite with great big arms; if you imagine that Lord Lansley was a satellite, I would come and grab him like this. I am not quite sure what I would do with him, but the idea is that the two of us would then plummet to earth together. Is that right? I am just puzzled because personally I think the debris problem is really serious.

Professor Hugh Lewis: Again, you are absolutely right. We can dispose of satellites into what are known as graveyard orbits, and we tend to do that for satellites that are at an altitude where there is not enough fuel on board to bring them back and destroy them in the atmosphere. A geostationary orbit is one example but typically, you need a huge amount of fuel on board in order to dispose of a satellite. It is a significant part of the fuel budget.

What that means for a commercial operator is that, essentially, it has to ignore the commercial benefit and revenue that it could gain by using that fuel to maintain its orbit. Instead, it has to use that fuel to dispose of the satellite. That is a conflict that has to be managed well, which is why regulation becomes so important.

You mentioned a satellite that could grab another one; this is probably where we are going to see solutions start to emerge in the future through in-orbit servicing; you can start to replace parts that are wearing out or refuel satellites, and so on. Instead of having to replace the whole satellite, you can continue to use it. That is a much better, more efficient use of the original resource. Ultimately, you can end up recycling, repurposing, even rebuilding in orbit without having to remove the object from orbit. That is being looked at very seriously as a potential solution for the debris problem, although there are certain policy and regulatory issues attached that need to be resolved.

Lord Shamash: Are those UK regulations?

Professor Hugh Lewis: Well, yes and no.

Lord Shamash: Sorry, I have had more than my say.

Q122 **The Chair:** We will have other members of the committee now; I am going to ask the next question, so that is even more important.

I want to focus on the space sustainability issues as they affect us. As I understand it, we are the first country to develop a space sustainability strategy and George Freeman, the Minister at the time, announced this at the London summit. First, do you think the measures that have been announced have been effective? Secondly, if you could make one recommendation to improve our policy on space sustainability, what would it be?

Professor Don Pollacco: The measures that were announced were all eminently sensible. When you look through the life cycle, all the things you would want were there. As I understand it, there are 130 signatures to the ESSI memorandum now. Whether that is enough—it is still early days, only a couple of years—I cannot say. The UK is a big supplier of spacecraft, but the reality is that until we get other international partners—Americans, Chinese—on board, then we are just part of this. It needs an international effort to be successful.

The Chair: Would your recommendation be that we have to get that?

Professor Don Pollacco: To me, that is what it would have to be. If the UK does this on its own, as George Freeman said, you could look at the implications for insurance. So if you are part of the ESSI you or your spacecraft could be insured at a cheaper level. That is the carrot, if you like. But the reality is that—just as with ships—there is always a Panama out there. If we have these fancy, really good licensing requirements, there is always a Panama that can do it cheaply. If we have services coming to this country they will have to abide by it, but business will take

the view that they have to be competitive. We need to bring some big players on board and then the tide will turn.

Dr Imogen Napper: It is incredible that the UK is leading the way in many aspects, but I really am from a different world, and I have similar views to the rest of the population. A lot of people are just not aware that this is happening. We were very lucky to publish work comparing the high seas treaty to an orbital treaty and why we need it, and further work comparing plastic pollution to orbital debris. My parents, my friends, and a lot of people at the university where I was working, were so confused that we were doing this in earth's orbit as well. It is almost as if we are in a pollution sandwich with our oceans being full of plastic and now unfortunately earth's orbits also filling with debris.

So my recommendation—maybe it is a bit bizarre—is to follow the tracks of ocean literacy in having space literacy, and showing the general public, all the way from schools to right at the top of Government, why we use earth's orbits, why satellites are needed and are so beneficial, but also the risks that are posed if we continue to overexploit this environment. We forget that it is still an environment of earth, and it often gets overlooked.

The Chair: The pollution sandwich is a great way of describing it.

Professor Hugh Lewis: Yes, I agree with that description. The measures that the Science Minister put in place back then were very sensible, as already mentioned, and they provided an impetus. At the time I was, and still am, a member of the core team for the Earth Sustainability Initiative. I helped to write the Memorandum of Principles and saw the reaction to it. Companies and individuals all wanted to be part of it because they widely understood that it was the right thing to be doing. They wanted to help shape the future of sustainability in space. That was how it was set out—it was going to be driven by industry—and that was great.

But as Professor Pollacco has mentioned, international engagement—which was another thing that was announced—is probably high on the wish list. I have to say that it has been very successful from a UK perspective. Engagement with the United Nations has been very good, and the capacity building, focus on sustainability and long-term sustainability guidelines have been tremendous. As mentioned, that is absolutely necessary because we need not just UK regulations and standards, but international standards. If you have different ways of working and operating and regulating around the world then you end up in this regulatory shopping environment where companies will go to wherever it is easiest to do what they want to do. We need to set a baseline and that is why the UK has started to do some really good work in international fora such as the United Nations.

Coming back to what Dr Napper has said already, there is a really big issue and a really big conflict to do with the commercial aspect and the sustainability and environmental aspect. There does need to be a

balance, but there is too much of a focus on trying to get all we want from space and thinking that a little harm is okay. We have come to accept that harm because of the benefits that we get from space. However, the issues that we are now starting to understand to do with the atmosphere and so on could be really significant, and we are potentially at a loss as to how to solve them. We have started to normalise harms to the environment for the sake of socio-economic benefit, and somewhere we need to find a better balance.

The Chair: Thank you very much. That is really useful.

Q123 **Viscount Stansgate:** The UK has made significant efforts to develop active space debris removal technology alongside the private sector. Has that money been well spent?

Professor Hugh Lewis: I would say yes for the simple reason that it is something that is needed. At the moment, we do not have any other recourse with respect to space debris, especially if we cannot always have spacecraft that are perfectly operational. Many spacecraft fail so we need a solution for those, and there are thousands of objects in orbit that are potential targets. To reduce that risk—remembering what we were saying about the number of objects in orbit being the concern—we need to bring that number down. So active debris removal is essential.

The UK has positioned itself extremely well to be at the forefront of the technology, to take the lead in terms of putting that technology into orbit and demonstrating its effectiveness, and potentially to conduct actual missions to remove debris.

I remember a remark from a colleague at NASA that somehow over the last five to six years the US has fallen behind the UK in active debris removal. I would always argue that it is something that is absolutely necessary and we have done very well to position ourselves in the way that we have.

Professor Don Pollacco: I see something of a conflict here. We may be making it cheaper to get to space, which means spacecraft cost less, but a removal mission will cost serious money. Professor Lewis mentioned earlier on that a longer-term solution is going to be recycling. I think there will be very few viable targets for this technology, but it is a stepping stone to a recycling environment. Imagine one spacecraft that goes and collects defunct spacecraft and puts them into a recycling centre; it sounds like science fiction but in the end that should be where we are going.

Let me also say, however, that debris is more than just spacecraft. Debris is little bits of stuff moving about at really high velocity, which is untracked at the moment, and that causes more debris. Somehow, we have to look after that as well.

Viscount Stansgate: You were making the point very effectively earlier that the number of untracked objects might potentially be 1 million, and of course, we do not know where they are or what they are. Have there

been examples, incidentally, of collisions that you can point to from untracked debris?

Professor Hugh Lewis: Yes; I am just trying to remember the year. One of the European Space Agency satellites was struck by what was estimated to be one centimetre of debris on its solar panel, leaving behind a 40-centimetre dent and loss of operation for that part of the solar panel. It is very difficult to actually attribute the consequences to small debris because it is small and untracked, but that one was visible because of the camera that was mounted on the satellite itself. There have been a couple of others as well where it has absolutely been suspected if not confirmed.

Viscount Stansgate: Can I go back to Imogen and ask the question about whether you think the money has been well spent. Is that something you want to comment on?

Dr Imogen Napper: It is something I would like to comment on. I believe that cleanups are incredibly useful and needed, but looking at the ocean and how much plastic pollution is going in on a daily basis, we have focused heavily on cleanups; they are effective to a degree, but not for the amount going in. They are very sexy: they make the headlines, and you can actually show that you have collected an amount of debris that would have caused a lot of mischief, but I fear that we are doing the same with space debris now.

It distracts us from the main purpose, which is trying to stop debris happening in the first place. We are trying to stop plastic going into the ocean and causing pollution in the first place. My supervisor at the University of Plymouth describes it really well; it is like an overfilling bath and what we are doing is mopping up the floor, but we could actually just turn off the tap. That would be the most effective way of stopping debris.

Viscount Stansgate: What do you think the future market is for what I call ADR? Are there incentives to buy these services without the type of international regulation that perhaps we all feel is going to be needed for it to be effective?

Professor Don Pollacco: There are some large spacecrafts currently orbiting that could be the source of a lot of debris and they belong to significant players. It would be in their interest to have these spacecrafts removed. But, as it gets cheaper to get to space, I do not think there will be a market. That is my view.

Professor Hugh Lewis: I take a slightly different perspective. I look at the geostationary orbit, which has been a commercial realm for many years. When you compare the statistics around the management of debris, in particular end of life and the management of satellites at end of life, it has always been very good in the geostationary orbit. The simple reason is that operating in a clean environment is better for the bottom line. If you are always having to manoeuvre, or worst-case scenario being hit by debris, then you lose your source of income, the revenue.

One of the things that we see happening now in low earth orbit is commercialisation. Constellation operators have an incentive to keep their orbits clean because it will affect their bottom line if they do not, and that is a very powerful driver for those companies. So there is an incentive already in place for companies that operate large fleets of satellites—where some satellites have failed, for example, and could be interfering with their own business—to conduct debris removal missions and maybe employ a third party to do that. So that is a potential existing market. Without that, the costs are so great that it is actually very difficult to point to anything unless the Government step up, or the international community steps up, and starts to mandate it. A mandate will probably still be required but at the moment my hope is that the commercial operators start to see the need to think about what happens if their spacecraft fail.

Dr Imogen Napper: I would add that I do feel like there will always be commercialisation in cleanup because it looks good and it shows that something is happening, even if it is maybe not the best solution in that moment.

This is a bit of a strange connection, but we did some research looking at how much pollution comes from our clothes; we washed them and found that 700,000 fibres could come off our clothes. We wanted to work with industry to see how we could try to capture the fibres before they go through the sewage plants and then potentially into the oceans. All the products we tested said that they were 100% effective in capturing fibres, but when we tested them, we found that only two were statistically significant in capturing over 50% to 70% of the fibres that were released.

So if we do go in the direction of active debris removal, we have to make sure that it is efficient and does not cause more environmental problems being up there than the debris it is trying to remove.

Lord Lansley: I wonder, Chair, if perhaps I could just trespass by asking a little follow-up.

The Chair: They all trespass.

Lord Lansley: Viscount Stansgate does. Starlink, for example, is a large constellation with a very high proportion of the total satellites launched. Just jogging back to the point you were making about regulation, is there any regulatory requirement on Starlink in relation to final removal or replacement or does it just put them up there and does what it likes when they fail?

Professor Don Pollacco: Funnily enough, my feeling is that Starlink is not the major problem. There may in the end be 30,000 of these, but they are in low orbit and that means that they are in the atmosphere. They have friction on them, and sooner or later they will de-orbit.

However, while I accept that you have to keep the orbits clean, the problem is that these are cheap satellites, very cheap satellites, the size of a fridge with a solar panel on. They are completely disposable, and they fail a lot. So I struggle to see how Starlink will clean its orbits of dead satellites at the moment. That is my view. But other constellations are coming that are in higher orbits.

Lord Lansley: Right, okay; so, they are not necessarily likely to enter orbit.

Professor Don Pollacco: They have a much longer period before they de-orbit.

Q124 **Lord Lansley:** Professor Pollacco, I am going back to what you said at the outset, that yes, they are all out there, but we do not necessarily know where they are. How successful have initiatives been at trying to find that out through space domain awareness, as they call it? In particular, how successful have the UK's initiatives been in that respect?

Professor Don Pollacco: You have come on to my hobby horse now.

Lord Lansley: Ride it away.

Professor Don Pollacco: Historically, the UK has not really had much of a capability. It used military capabilities such as Fylingdales and very little else. That has started to change in recent years; more capabilities are coming online, and the UK can buy data from other suppliers around the world. However, in this world we live in, we need an indigenous source of data that we can trust; that is becoming more and more important as time goes on. So some effort is being made, but what I would say to my hobby horse is that this is a place of research. There are ways to make this efficient. There are ways to lead the world in the collection of this data and there is a community that could help in this.

Lord Lansley: Presumably, there is a military requirement and a civil requirement. In respect of the civil requirement, presumably it is pretty straightforward; if you have data that people want then they will pay for it. The military is probably separate from that. It often has data that it does not want to sell.

In the UK through, I think, the National Space Operations Centre, are we potentially arriving at an international standard of data for which we could be a market?

Professor Don Pollacco: When the NSpOC was set up as a collaboration between Government, military and commercial operators, I did wonder how it would work given their different requirements. So far—though maybe just because I do not have a view into it—it does seem to be working.

From the point of view of tracking, when you are tracking satellites, you are tracking objects. You do not even have to know what they are and the interpretation can happen at the NSpOC level. So they can coexist in

that regard at that point in the NSpOC, but I think there is an opportunity for the UK to develop its own tracking environment.

Lord Lansley: Are we notably better equipped where this is concerned, or are others way ahead of us?

Professor Don Pollacco: In other countries it is often a commercial enterprise. They sell data, to Governments mainly, at what could be extremely good rates for them. In this country I do not think we take advantage at a national level of the capabilities in the community, at least to design new tracking systems. Like I said, a lot of this material is untracked, but it does not have to be.

Lord Lansley: Professor Lewis or Dr Napper, do you wanted to join in on riding this hobby horse?

Professor Hugh Lewis: If I can come in very briefly, although this is not my area of expertise in particular, I would say that this is not just about data. It is also about the services that come from that data that you need to provide to operators.

In the UK we have an environment with lots of expertise about how to convert data into meaningful, useful products such as might be needed, for example, for collision avoidance; as I have mentioned, this is becoming very important. So it is not just about developing sensors and accessing data, it is also about those services. It is about converting the data into meaningful knowledge.

Dr Imogen Napper: I would completely agree with my colleagues that data and research really are powerful. It would make my life far easier if there was a way that I could track all the plastic in the ocean. As plastic marine scientists, we spend a large chunk of our time trying to understand where the plastic is going, where it is flowing to, and whether it is crossing international boundaries. We have the opportunity now to do that with space debris. With plastic, we spend so much time trying to understand where the debris is accumulating and that is where we really input different solutions—cleanup or legislation. There is a mirror image here.

Q125 **Baroness Mobarik:** We have touched on some of these points already but, given the explosion in satellite launches, especially from mega constellations—someone mentioned Starlink—concerns about orbital congestion and the risk of collisions, what are the prospects for international regulation to regulate the creation of space debris? Is there an appetite for it?

Dr Imogen Napper: I would say that there has to be an appetite for it; it is not an option anymore. If I can make comparisons with the plastics treaty, it has been incredibly slow to even have these discussions and this international collaboration, and it has been very messy. But we have had centuries to damage the ocean and only decades to damage earth's orbit. We can use that as an example of why we need to work together now. It is not, "Can we", it is "We must".

Professor Hugh Lewis: Thank you for the question. It is actually a very difficult and fraught topic. My answer is to tell you about a conversation I had with Aarti Holla-Maini, who is from the United Nations Office for Outer Space Affairs. Aarti said that there is no appetite for, and no possibility of, negotiating a new outer space treaty; in the current climate, it is going to be very difficult to do that. However, what we can do is work together to establish space traffic co-ordination and ask how operators and countries can speak to each other to resolve issues in space and to work towards transparency. That is a really fundamental part of what is needed for safe and sustainable operations in orbit.

A huge momentum is building around space sustainability. We can look at the long-term sustainability guidelines that the United Nations produced as a really good template, and my hope is that there are more of those to come. But that is where the focus is sitting at the moment—on those international guidelines. States can point to them and implement them into their national practices and ways of working, knowing that a consensus has been built around them. So the regulation, the law if you like, happens at a local level.

Professor Don Pollacco: The main stick you could use is that, if you want services to this country from satellites, they must be licensed by the UK and they must abide by the principles of sustainability. If you can do that with other countries, then it will automatically get adopted by the bigger players in the world. But it is a very dangerous game. As I said earlier on, you end up with a Panama situation, but if we do not accept those services from people who are unregulated by us, then we lose out. I am sorry, that sounds very negative.

Baroness Mobarik: It is very heavy.

The Chair: Do you think that is also true on the prohibition of weapons testing?

Professor Don Pollacco: Can I say I am not an expert in this?

The Chair: I do not think any of us are.

Professor Hugh Lewis: There is an appetite. The UK is already part of an agreement to ban direct-descent anti-satellite weapons because those are well understood to be harmful. If you look at most satellite operations you cannot point to the harm very easily, but anti-satellite tests are a very obvious thing that we could see consensus building around.

The Chair: Thank you very much. The last question is from Baroness Bonham-Carter.

Q126 **Baroness Bonham-Carter of Yarnbury:** This being the last question, it has maybe been answered already. Picking up on what the Chair asked you earlier about our role in space sustainability, the UK is engaged in high-profile space diplomatic efforts via the UN, the Earth Space Sustainability Initiative and King Charles's Astra Carta Initiative. I know you both said that there is no international agreement on these things at

the moment, but what is your opinion of these efforts? Are they actually pushing at an open door?

Professor Hugh Lewis: First, I should declare that I am a member of the Astra Carta Advisory Council and the Earth Space Sustainability Initiative, so I can offer an insider view.

Baroness Bonham-Carter of Yarnbury: That is always good and always welcomed.

Professor Hugh Lewis: I am possibly not completely objective as a result. I think these initiatives are really welcome and really necessary. The way in which they are being conducted by drawing together academia, Government and industry is the right approach because you have the right blend of operational skills as well as research capability, expertise and understanding. The one thing I would say we probably need to do better is in our engagement with the public who do not necessarily understand the value of space.

Baroness Bonham-Carter of Yarnbury: That is what Dr Napper was saying earlier.

Professor Hugh Lewis: Yes, indeed. But these initiatives are really welcome, and they each have their place in terms of who they can speak to and who they can attract. Astra Carta is industry focused but also has a public arm, with ESSI, industry, academia and Government, working hand in hand. There is an opportunity there to build international collaboration as well.

Dr Imogen Napper: They are incredibly symbolic, they create discussion and that really brings people together, which is fantastic. But I hope that it is more than just discussion. What we have seen with debris on our planets and in the ocean is that we are very good at writing declarations or potential policy pieces and saying what needs to happen, but right now we need to be confident, to actually open the doors and do it. We need to see that action and this is a fantastic opportunity for us to lead the way, steer the ship and hope that other nations jump on board as well.

Professor Don Pollacco: I just want to answer a slightly different question, and I will make a small statement. There are thousands of tonnes of things such as rocket boosters in orbit in space because in the old days we would launch something into space and the booster would go into orbit. It will still be sitting there, and it has never been decommissioned properly. It will not decay in a few years and every now and then there is a pop and a big cloud of debris comes out. If we are going to remove anything, we should be taking those apart now. They are the source of a lot of debris that is on the way to creating our own little Kessler situation. I just wanted to get that one out, so you realise there are thousands of tonnes there already.

Baroness Bonham-Carter of Yarnbury: Can I ask a supplementary? You have all said—it seems so obvious—that there has to be an

international agreement. Would that be genuinely international? Does it include China, Russia, the US, Europe?

Professor Don Pollacco: One of the problems is that not everyone knows where spacecrafts that were launched 50 years ago are, and the ownership of them is not always straightforward—not in every case anyway. For the ones that we know about, under our ownership, they are our spacecraft and we have responsibility for them. That should be the same for everyone. So removing those spacecrafts, or dealing with the debris problem is our problem, and other countries should stand up to their problems as well.

Professor Hugh Lewis: International collaboration is vital. I will leave it at that.

The Chair: Thank you all for coming to give evidence to us. We have just made it in the hour, which is fantastic, and you have been extremely generous in your responses. I thank you all and formally conclude this public evidence session.