

Defence Committee

Oral evidence: Space Defence, HC 271

Tuesday 13 July 2021

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Members present: Mr Tobias Ellwood (Chair); Stuart Anderson; Sarah Atherton; Richard Drax; Mr Kevan Jones; Mrs Emma Lewell-Buck; John Spellar; Derek Twigg.

Questions 1-42

Witnesses

I: Dr Mark Hilborne, Lecturer in Defence Studies, King's College London, and Dr Mark Presley, Consultant on space policy and strategy, MAP Analytica.



Examination of witnesses

Witnesses: Dr Mark Hilborne and Dr Mark Presley.

Chair: Welcome to this Defence Committee hearing on Tuesday 13 July 2021, when we will be focusing on space. I am delighted to welcome our two witnesses today: Dr Mark Hilborne, who is a lecturer in defence studies at King's College London, and Dr Mark Presley, who is a consultant on space policy and strategy at MAP Analytica. Sirs, you are welcome this afternoon. We are very keen to hear your thoughts on a wide range of views involving this new area of concern and opportunity, with the emerging threats that we have from space.

This session is intended to be a wide-ranging exploration of the issues covered in the terms of reference that we have on our study here, and an opportunity for the Committee to explore the challenges and opportunities of the current space defence landscape with our two experts. Gentlemen, you are more than welcome.

Q1 **John Spellar:** I will kick off with a scene-setter for this session. What is your assessment of the UK Government's recent efforts to progress the issue on the international stage?

Dr Hilborne: I can perhaps start with this. I think you are talking in particular about the recent resolution for responsible behaviour in space, which I think is one of the first positive steps that we have seen in terms of governance in space for some time—so I think that the Government should be commended on pushing that through, and Ambassador Liddle for doing so.

This starts the discussion into what we might see. It is not a binding resolution and not a binding treaty, I should say, that limits any types of behaviours, but it starts the conversation on what responsible behaviour in space should look like and what we can agree on. I think those are quite important. At the moment, there is not much strategic dialogue happening between the larger spacefaring nations. We often wait, I suppose, for that opportunity to arise, but I think these kinds of negotiations can further the understanding between states and develop that, so it is not like we should be waiting for the right moment for this.

I think it is quite right to push this forward as it becomes particularly important. Space is becoming very congested, contested and competitive, as the saying goes. The time is ripe for that kind of discussion, so it is excellent timing, and it certainly puts the UK forward in terms of being a centre for space governance.

We have argued before that London has a great history in terms of financial regulation, insurance, et cetera. It is also a good place to be discussing space governance, and is a good home for that, so I think that those are very positive steps. There is still a long way to go if we are



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thinking about treaties and arms controls, but none the less the number of states that signed up to the resolution was quite significant.

Q2 John Spellar: So you are saying that there has been a decent degree of resonance to this initiative.

Dr Hilborne: Yes, I think there has been. Russia and China have not, but none the less that does not mean that it can't happen in the future, or that future iterations on space governance could not include them. At the moment, they have not, but none the less I think it was 160 or 165 states that signed up to this—so quite significant.

Q3 John Spellar: Anything to add, Dr Presley?

Dr Presley: Yes. I fully agree with what Mark is saying. You talked about the resonance of it all. The support that it gained in the UN—I think 162 states supported the resolution—was quite significant. I think the resolution hit just at the right time, as the question of congestion in space is really beginning to rise to the surface of a national debate on space sustainability. This is particularly on the back of the rise of the so-called mega constellations, where LEO—low earth orbit—is being populated by an increasing number of satellites.

Indeed, just the other day with Richard Branson and Virgin Galactic, there was the space tourism launch. While that didn't go orbital—I think it went to 83 km in space—it still raised the potential issue of space tourism, which will add to the debate about space surveillance and space sustainability, with actual life involved rather than satellites alone.

The debate on space surveillance and the need to understand that environment a lot more clearly is part of that background, and what has created that resonance through the UK leadership on that resolution in the UN.

Q4 Sarah Atherton: United States Space Force and United States Space Command have a budget of \$40 billion per annum. We are obviously a smaller country with a smaller budget—a £6 billion core programme and a £1.5 billion uplift over the next 10 years—so we will need to rely on our partners, namely the USA. How do we keep earning a seat at the table?

Dr Presley: That is a very good point. The seat at the table has been earned over a long number of years through our close relationship particularly with the US, which is our single most important ally in space relationships.

I would suggest that the seat at the table is built on a long history of our contribution, in terms of places like RAF Fylingdales and the radar there that contributes to the Ballistic Missile Early Warning System. That is its primary role, and it also conducts a great deal of space surveillance.

On top of that, we have had a lot of people on exchange posts with the Combined Space Operations Center and the 18th Space Control centre at Vandenberg. That linking of the two has been very extensive and has built that relationship, so I think the seat at the table is there.



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This is less my area of expertise, but I am aware that there is a very close relationship between the intelligence and security communities as well. That has given us access, which has been a great boon to the UK over the years.

If we want to look at more nationally assured sovereign capability, we need to look at where we can contribute that does not replicate the contribution that we get from the US but adds to it by filling some of the gaps, perhaps by looking at some niche capabilities that we can fill. The space surveillance capabilities that the US offers are world leading; we could not hope to match that at all. Equally, we have quite a bit of expertise, built up through our experience at Fylingdales and the UK Space Operations Centre down in High Wycombe, with commercial support from companies such as Serco.

We have a great body of expertise there, and the No. 1 priority that the UK space director has mentioned on a number of occasions is space domain awareness. Perhaps that is an area to which the UK could contribute by adding one or more sensors to that space surveillance, perhaps located in areas where there are currently few sensors. Sensors depend on which part of the orbit you can see. I think we do earn our seat at that table, particularly with the US, but there are still niche areas that we can build on. In-space surveillance is one particular example where we can contribute to that already very good capability.

Looking closer to home at our European allies, because we have been so privileged in the access we have had to the US capability, we perhaps have not developed our sovereign capabilities quite so much, whereas our European allies make small contributions to NATO. Therefore, as we look at our position, having that UK sovereign capability is something we could look for. Space surveillance, which I have mentioned, is perhaps one, but perhaps the UK could have a broader look and do some horizon scanning to the future to see where those other niches might be so that we can add to the contribution we make to the seat at the space table.

Dr Hilborne: I entirely agree. The alliance with the United States tends to be the main strapline. That is true in the UK, Canada and Japan. You can see in all their space policies that it is particularly important, so it is about finding niche areas where we can contribute and where the US might be slightly light on certain specific capabilities or areas. As we said, southern hemisphere sensors for space situational awareness would also be extremely useful to the US. There are particular constellations that might be able to produce certain things, such as the Canadian Sapphire satellite, which is space situational awareness from space.

There is a lot of innovation in the UK: there are more space start-ups in the UK than in any other nation after the United States and possibly China, so there are a lot of pockets of expertise. It is about finding innovative and cost-effective ways to identify some of these niches and bring cost-effective solutions to them. Our papers have focused particularly on space situational awareness, or space domain awareness as it is now called, which is able to contribute, without a great outlay, to the broader picture



of space. It is definitely identifying these niches where we might complement the US. Instead of just being a net benefactor, we are also contributing to the dataset that we are all using.

Q5 **Sarah Atherton:** Space is obviously bottomless, as is the finance, the money, that we can throw at it. It is sort of my understanding that the Government need to consider the UK sovereign requirements and capacity, as Dr Presley said, and the UK prosperity agenda and our international partners. In the middle of that is the term that I think they call "space proposition", which you probably know more about than me. How do we capitalise on our allies and their capabilities, particularly thinking about the Five Eyes?

Dr Presley: I refer back to what I mentioned earlier. The US defence strategy that came out in June last year called for expanded information-sharing relationships with capable allies and partners and called to align on space policy. To achieve that, the UK must first have some data to share and a policy to align.

I think the National Space Strategy will be part of that jigsaw, and I think having a UK sovereign capability allows us to make that contribution. Regardless of how small it is, it is a contribution and it is a sovereign capability that gives us control of a national asset.

Mark mentioned perhaps a radar in the southern hemisphere, which would fill a current gap in the global space surveillance coverage library, if you like. That is an example of how we could achieve that, and achieve it with relatively small costs. It depends on the capability of the sensor and how it links in to any operation centre, and how large that might be, but we are likely to be talking about the tens of millions of pounds, rather than the hundreds of millions or billions.

For a contribution that is within the UK scope, it could still make a significant contribution, not least to the US but to the global space sustainability debate and space prosperity you talked about more broadly. It is identifying that and other similar niches to which we can contribute. I don't think we have to look to do everything, nor should we look to try to replicate what already exists. What we are looking for in space, which is very much a global enterprise, is to find those areas where we can make a contribution that is then valued across the globe internationally, and then with a quid pro quo, gain access to some other sensors that might be out there.

Dr Hilborne: We have seen a slight change in tone from the US in the past few years. There is a call for allies to do more to help bring that composite set of capabilities to space, as we see challenges for instance of a rising space power in China. There is a desire, from the US for instance, to see more capabilities from a number of allies, and that is where the UK can look to capitalise. As I mentioned, there is a lot of capability here.

Surrey Satellites is a brilliant example where we see the standard design, what we call the satellite bus, being used for a number of different satellite



systems. The Canadian Sapphire satellite is a Surrey Satellite design. There is a lot of capability here on which we can capitalise, for example, industrial, as well as thinking about some of the other elements such as big data and analytics and elements like that. It is not just the hardware; there are a number of elements that we can build on where there is a lot of experience and capability in the UK.

Chair: Thank you for setting the scene from a UK perspective. Let us now pivot across to see what other countries are doing.

Q6 **Mr Jones:** In recent years, there have been significant developments in terms of China's counter-space measures; we saw the destruction of a satellite, for example. Could you tell us about your understanding of what the Chinese are doing? In terms of the threat from either China or Russia, which one poses the most challenge for the west? Dr Hilborne, do you want to go first?

Dr Hilborne: We see different types of threats in space, which we can characterise as kinetic and non-kinetic. What captures our attention the most are the kinetic kinds of weapons, what we would call direct-ascent anti-satellite weapons, co-orbital weapons—a satellite that has the same orbit as its target—and perhaps attacks on ground stations.

You are quite right that both Russia and China have active counter-space programmes that involve things like direct-ascent anti-satellite weapons. We have seen China conduct both the tests I think you are referring to in 2007, with probably some flight after that, plus what is potentially an intercept, or a test for an intercept, in geosynchronous orbit, which is something that we have not seen before. If that is true and was actually the case, I would argue that that is a more significant threat than Russia.

Russia has developed the Nudal system. It had a number of flight tests; it has not had a physical intercept yet. Probably their S-500 surface-to-air missiles are anti-satellite capable. We are not quite sure. We have seen statements saying different things about that.

Both present a threat. What is interesting to look at, though, is what we call the non-kinetic threats in space: things like jamming, dazzling or spoofing, or cyber-attacks. As we have more and more in space, it seems to me that a physical attack makes less and less sense, particularly if you are a nation with a lot invested in space and a lot of dependence on space. That would surely characterise China as we go forward.

The direct-ascent anti-satellite missile systems made a certain amount of sense in the cold war perhaps, when we had a fraction of the number of satellites in orbit, but today there are so many that any kind of intercept would create the risk of fratricide. I think that for states like China, the more reliant they are on space—this is a personal opinion—the less likely they are to conduct those kinds of attacks in space, and perhaps similarly, Russia.

Q7 **Mr Jones:** With the non-kinetic threats you have just outlined, what is the entry level? We have seen, for example, China, Russia and Iran using



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proxies for cyber-attacks. Is the level of technology needed state level, or could there be plausible deniability of being part of an attack, if that was wanted?

Dr Hilborne: That depends on the size of the attack and—say you are trying to jam the GPS signal—the extent to which you want to jam it, over what kind of area. At the moment, that is state-based technology. We are also talking about two different systems: the GPS non-encrypted and encrypted signals.

The encrypted signals of the military are much harder to spoof or manipulate, though you can still jam them. The non-encrypted signals are fairly weak and easily jammed. We have seen a number of different cases of China and Russia perhaps doing that. There was an instance in 2017, in the Black Sea, when Russia was accused of manipulating a GPS signal. A lot of shipping found itself well off course. It does depend. Car thieves can do this at a very local level, and so on upwards from there.

When it comes to cyber-attacks, that probably is quite a significant capability, or spoofing a satellite, because that needs quite sophisticated capabilities, so you have to make the end user think that the signals they have are credible. That is quite difficult. It is not just a matter of jamming a signal; it is a matter of replacing information with false information. That is a matter of sophistication. I would imagine that, as we get more and more commercial actors, and that kind of technology proliferates, in the not-too-distant future that will become easier and easier.

I tend to think that that is the kind of threat we will see more of, either in so-called peacetime or in conflict, because it is deniable and it is hard to respond to. How can you deter an actor from something you cannot really attribute, or it takes you a long time to attribute? That requires a rethink about our notions of deterrence and retaliation.

We have to think instead about resilience because it becomes very hard to respond to that kind of attack, at least in a timely way. It is difficult to know where it has come from. Some of these things can appear to be space weather, but we do not necessarily know where some of these problems have originated. That probably then requires a rethink of how we retaliate and respond.

I tend to think that those are the most likely and consistent issues that we face, rather than things like direct-ascent anti-satellite missiles. We know exactly where those are coming from; we can track them. We know that so and so launched this at such and such a time. The sub-threshold attacks are much more difficult to pinpoint and respond to.

Dr Presley: I will just add a few points on that. Mark has covered well the general direct-ascent attacks, which often get the headlines, and rightly so. He identified the fact that the more nations around the world are reliant on space-enabled capability, the less likely perhaps they are to impair that capability by making that sort of attack. It is still a viable threat and one we need to be very conscious of, so I do not dismiss it, but



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the associated threats and hazards in space are equally viable in terms of where we should focus attention.

The jamming, spoofing, dazzling and cyber threats that Mark touched on are most definitely areas of threat that we need to be aware of and build resilience to in our space infrastructure. Equally, the ground segment that supports all our space capability needs to be adequately protected. It is probably as vulnerable as anything else. Then there is the additional challenge of looking at space and all the various objects that are out there and identifying what they are and what their intent and role is.

There is an interesting opportunity to extend the life of satellites in orbit by in-orbit refuelling, repairing satellites or dealing with debris—trying to de-orbit some of the debris up there. All of those capabilities require the technology to launch and manoeuvre in orbit to get into close proximity with another satellite. Those are absolutely genuine commercial opportunities, but that is the same technology that, in the wrong hands, or used nefariously, could pose a threat. Therefore, some knowledge of the environment and what is happening out there is essential to monitor and regulate threats.

The defence term “space domain awareness” is a very good one because it extends beyond the space environment to all those other elements we have just described about jamming, the cyber elements, the ground segment and intelligence on potential threats. The term describes more fully the whole range of threats that we might need to consider.

Q8 Mr Jones: One of the counter-measures to that is obviously resilience—making sure that you have other capacities. No nation on its own is going to be able to do that. Is any work going on in collaboration with international partners on getting that resilience into the system?

Dr Hilborne: Shall I take a pop at that, Mark?

Dr Presley: By all means, go ahead.

Dr Hilborne: We are seeing a realisation that low earth orbit constellations offer a certain resilience, as opposed to, say, very expensive GEO satellites that might be a rather easier target. Disaggregating your capabilities over a constellation of small satellites in itself builds resilience.

Going back to an earlier question, if you have more allies working together, you have different systems. That complicates, let us say, an attack on a system—the French, the Australians and the United States all have slightly different systems in different places, which complicates the calculations that an enemy has to make. Those are aspects of resilience that are built into these systems. We are certainly seeing a change in the United States. It is looking at more and more constellation-based capabilities as opposed to what went before, which was large, expensive GEO satellites.

There are a number of ways of building in resilience. We often talk about being able to reconstitute our capabilities, so if something is taken down,



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to relaunch it. That is extremely expensive but as we get cheaper launches that becomes more and more viable, but that is quite difficult. Building in that resilience by disaggregating your capabilities over a number of different platforms via different countries adds a great deal of resilience in itself.

We talked about space situational awareness and space domain awareness. Already, if we think of the Five Eyes, we have a much broader capability than China will probably have for a long time because it does not have natural allies. Its ground segment is mostly based in China, but we can count on Australia, North America, the UK and Europe, to a certain extent. Even that alliance structure is a level of resilience the likes of which Russia and China cannot count on at the moment.

Dr Presley: I reiterate what Mark said about resilience and the built-in resilience that comes from having allies and the dispersion of the ground segment of the space capability around different territories, which makes it in itself much more resilient.

Part of that question is asking ourselves what part of the UK space capability needs to be owned IP sovereign, because that is the bit that you will have absolute control over in a crisis, whereas allies' tasking may be taken elsewhere and you might not be able to have full control of it. So, part of that resilience is asking, "Well, which parts of the system do we need to ensure we will have complete control over and build in the security measures to defend that?" What they are, I don't know. Perhaps there is something to do with critical national infrastructures. Again, an awareness of the space domain is certainly something that should be central to all that.

The resilience comes from dispersion through working with allies and identifying what is important to the UK. For example, Skynet is a satellite communication system that has had a long heritage providing satcom for defence. That has various resilience measures built into it to ensure it can continue to operate. That will probably need to apply to some of the other areas of critical national infrastructure as we begin to think about space more overtly, as the Chair mentioned right at the beginning.

Q9 **Chair:** Thank you very much. Just to probe that a little bit further, you mentioned jamming, dazzling and spoofing. Did I hear you correctly? What is spoofing?

Dr Hilborne: Spoofing is where you essentially replace the information with false information. You are able to spoof or pretend that information is credible, so that you are giving false navigational co-ordinates, for instance, through the system. As I said, that is relatively sophisticated and hard to do.

Q10 **Chair:** We get a lot of that in politics as well, actually—changing the message. Before we go down that particular avenue, my question would be if there was to be a major peer-on-peer attack on us, would it not be the arena of space where we might first see evidence of this? Would you



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agree that taking down our satellite systems, given how hugely reliant our military capability is on them, means that that is where we are now most vulnerable?

Dr Hilborne: I would agree that it is a massive vulnerability. It rather a strange juxtaposition that the largest space power, for instance the United States, is also the most vulnerable as it is most dependent upon it. Nonetheless, as I said before, as states become more and more reliant on space—China, for instance—they are going to have to be extremely cautious about what they do in space. You saw the debris that came from the 2007 anti-satellite tests. That is the kind of thing that can create a series of other collisions and that creates a grave threat to your own satellite system. So, as China grows in space it is going have to be more sensitive.

I think that balances that threat out. I don't know that it would be the first, but we see people commenting on China and translating documents that show that China might see that as good for a shot, in many respects, in its kind of war with the United States, but that is something that will require cooler heads at the time, if that were ever the case

Q11 **Chair:** This is all state actors, but we have seen how non-state actors take something very powerful and use them to their own advantage, in dirty bombs and so on. I could see a non-state actor enjoying the idea of prompting or triggering the Kessler effect—the tumbling of all the satellites, causing just a mesh around our world so nobody is able to benefit, taking us back to the 1950s. There is a lot of debris up there anyway—there are spanners that astronauts accidentally let go of in the 1960s. How concerned are you about the Kessler effect being triggered?

Dr Presley: It is an interesting question and talks to the increasing congestion in space and the issue of space debris and space sustainability, which is of concern not just to defence and the military but more broadly. Therefore, we should most certainly be concerned about that.

On state actors or non-state actors and the nefarious activity you talked about, I think there may well be indicators of that, which we could act on. Equally, I would suggest that the non-state actors that you perhaps alluded to are probably just as reliant on space capability as we are. They probably do carry mobile devices—perhaps disposable ones, I don't know. They probably use something like Google Maps. They use satellite communications to communicate with various cells in some shape or manner. To think that they are not reliant on space-enabled capability is a little bit light these days, because space is so penetrating into every aspect of life. The question is how willing they might be to lose all that—I do not know.

How easy would it be to create a Kessler effect? Again, it is very difficult to ascertain that. There is variance about the volume of debris out there. ESA and NASA disagree by almost an order of magnitude—between 500,000 and 900,000 objects below 1 cm. It is a big question how that Kessler effect could be created.



But I think your question is a really valid one. Having a focus in the UK across the defence, civil and commercial sectors, which could be a focus for picking up the indicators for that, would be a really positive step for the UK to take in that direction. We currently have the space operations centre based at High Wycombe, which does a fantastic job with some great access, but that is limited in its ability to speak to the wider civil and commercial community via the release of that information to which it has access. Having a more open space operation centre to act as a focus for identifying the indicators of any nefarious activity in space should be the UK's first big step in better understanding the environment, and then being able to take the action early on to counter any threats, whether state-based or non-state based.

- Q12 **Derek Twigg:** Dr Hilborne, you talked about retaliation, but said it is better to have resilience. I would like to delve a bit deeper into those things, following on from Kevan Jones's questions. On resilience, being agile will be quite important—being able to respond quickly and think ahead about potential threats. Where do you think we in the West and in this country are in doing that? On retaliation, do we do enough of it?

Dr Hilborne: In space, do you mean?

Derek Twigg: Yes.

Dr Hilborne: There is a good point there. We talked about the non-kinetic kind of attacks, which happen fairly frequently. We might argue that we are building a precedent by not responding to those, partially because Mark just identified some military classification—we do not want to talk about some of these things. We don't want to talk about how we know about some of these things.

We don't want to talk about how we know about some of these things. So, some of these activities—dazzling with satellites or other kinds of attacks—go unpunished. In that respect, maybe we are not doing enough, but when we say retaliate, we do not want to necessarily shoot back, if you see what I mean, because of things like the Kessler effect.

The United States, for instance, does not seem to have the same overt development of anti-satellite systems as China and Russian. It has an innate capability. One of the difficulties in identifying those is that anti-ballistic missile systems are often very similar to anti-satellite systems, so a state may well have a hidden anti-satellite capability. Obviously, the US has that capability, but it is perhaps slightly less overt in developing those counter-space weapons.

So we have to be very cautious. If we have a lot at stake in space, we have to be very careful about how we strike back. If we look at deterrence theory and the whole idea about the three Cs, one of those is communications. It is really identifying the red lines and saying, "If a certain attack happens, this is what will happen in response."

That was all developed, of course, with a very singular weapons system, in a very singular bilateral dyad, where it was the US versus the USSR.



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Today we are talking about many, many space actors and, increasingly, there are non-state actors—commercial companies—that will have a lot of capabilities in space. How we can conceive of, let's say, a deterrence in space in that complex and slightly grey zone becomes very difficult, so I think we have to be extremely cautious about this aspect of striking back.

It is not to say that we should not develop those capabilities, but I think we have to be very cautious. At the same time, as we look at things like multi-domain integration—this idea that it is a comprehensive approach where all the elements of the Government are working together—if we think about the UK's efforts in establishing responsible behaviours in space, one thing we can argue is that any kind of weapons system in space is barred by the outer space treaty. There is a bit of a legal debate about that.

One has to balance those efforts about responsible behaviour in space with weaponising space or placing weapons of some kind in space. That has to also be carefully balanced—thinking about all the elements of government and how we piece that together. Is that what your question was driving at?

Q13 **Derek Twigg:** Yes. Dr Presley, have you anything you want to add?

Dr Presley: Talking about resilience and agility, the difference between a Defence space capability and a civil or commercial space capability is blurred almost to the point at which they are indistinguishable now. Therefore, any resilience or agility Defence has needs to be equally available within the civil-commercial domains as well. Therefore, a joined-up approach to space across Government would be the first step in increasing that agility, so we could move capability between commercial, civil and Defence assets.

Going back to space surveillance, part of the deterrence that Mark talked about with communication, is being able to detect some bad behaviours in space and calling that out to actually communicate that we are aware of somebody's actions—to communicate that deterrence point of view. Deterrence can be achieved in a number of different ways.

The resilience point you mentioned is more joined-up government to observe space and what is happening, manage our assets across the three sectors in a better way and be able to communicate the fact that we know that to any nefarious actors that are out there.

Q14 **Derek Twigg:** You talk about joined-up approaches between Governments. Do you think we are at a good position in that, or does more work need to be done?

Dr Presley: We are moving in the right direction, but more work needs to be done for sure. I would imagine the National Space Strategy might point more in that direction. We shall find out when that is released later on this year. Certainly, there is an increasing moving together of Government Departments, but still it is quite fractured. For someone sitting slightly outside of Government who tries to link between academia, Government



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and industry, I think it would be fair to say that the view is that it is quite fractured at the moment, but moving in the right direction. The more we can do that, the more resilient and agile the UK will be in managing its space capability.

Q15 **Derek Twigg:** Who, in your view, would be responsible for getting a grip of that to make sure that it is done much more quickly and smoothly? I mean, where is it falling down?

Dr Presley: The National Space Council has sat a number of times; I don't know exactly what has come of that. I am not sighted on that, but I am sure there have been some very positive moves within there.

However, for example UKspace, as part of its CSR submission last year, submitted a paper called "Modernising UK Space Power", which referred to a space delivery agency that would sit underneath the National Space Council, or something like that, to help deliver it.

There has been talk of having something like a SAGE for space, or some sort of strategic advisory board, which would advise the National Space Council in a way that was coherent and cross-Government. And also, to do something in a paper that Mark and I wrote, perhaps having an aggregated space budget across UK Government would allow spending to be achieved without it falling to one Department or another. That might increase coherence.

Whether any of that is achievable, I am not sure, but certainly those are suggestions that might move towards having more coherence across Government. But, as I say, it is certainly improving.

Dr Hilborne: I would just add that it is not to be underestimated. We do not have a national air policy or a maritime policy, so bringing together these different components, which maybe have divergent interests—we can argue, perhaps, that there is more of an overlap in space than in other domains. None the less, they are divergent interests. Putting that together is no simple task.

I think that, as Mark has alluded to, the macro effort is nicely joined-up and I have been pleasantly surprised at the willingness to work together. But of course there are a lot of institutional walls to break down.

Where we have traditionally seen a problem in space has been the level of classification. The military hoards all the information. If you look at the cold war, most launches were between the US and the USSR, and 75% of those were all classified military payloads. Today, it is very different; there is a much higher commercial emphasis.

There is this latency, though, for things like military classification. And I have been quite heartened by, for instance, the RAF's attitude that this needs to be transparent and open, as much as possible. Of course there are elements that will never be that way.



So, I think the willingness is there. I have sat on a number of roundtables from all across different groups looking at the National Space Strategy and there is definitely that willingness. It is breaking down some of those walls that I think will be harder to do.

However, like I said, we have not done this in other domains. It may be an advantage of the UK being a slightly late adopter that there aren't so many vested interests, such as in the US. So, we have that opportunity here. It is no easy feat, but I think the will is there at the moment, in the broadest sense at least.

- Q16 **Derek Twigg:** There seems to be a need to have a go-to person in Government, or someone who you can actually say, "Well, they have got responsibility for driving this", whether it is the Prime Minister or a Secretary of State from a particular Department. From what you are saying, I gather that that does not really exist as such.

Dr Hilborne: "Space is our sort of thing"—no, not specifically. And again, as I have said, we would not necessarily expect that in the air domain, where you have military air and you have a civilian air industry. But because there is an overlap in space, I think that it would be easier to achieve in that domain than in other domains. That would be quite handy—or at least a SAGE, like a body or a council that sits below the National Space Council and that can pull together these often divergent needs and divergent budgets, and try to find ways where some of the commercial developments will be useful to the military, and vice versa. We have argued that space situational awareness is something that serves everybody's interests.

One of the points we argue is that it could be a bit of a catalyst for these different elements within the space sector to come together, because everybody needs a recognised picture of what is going on in space. That is one of the reasons we chose that as an area, as a fundamental building block, in that it could help to cohere these divergent elements within the space sector.

- Q17 **Stuart Anderson:** I want to expand on the points that you have just raised there about a willingness, but there are also complexities around what is occurring in space. Would it be reasonable for us to believe that there could be an international consensus on what is acceptable in space? What would be the complexities or characteristics unique to space that might prevent that from happening?

Dr Hilborne: While we might argue at the moment that there does not seem to be—when I was talking about willingness, I meant cross-Government, not internationally. Certainly, in the UK, I think we see the commercial sectors, industry and military working together. Internationally, that is quite different. At the moment, there is this deficit of strategic dialogue and agreement, and that has got worse and worse between the US and China in particular, and between the West and Russia. That does not mean, though, that it is not in everybody's interests



to find some kind of basic position of space governance and, from that, to build perhaps a wider understanding.

We are finding now that the kind of things we are doing in space are developing quickly—things like rendezvous proximity operations, whether for maintenance or manufacturing or refuelling. We are going to be seeing a lot of less standard orbits. We are seeing more and more in space, smaller and smaller; it is becoming much more confusing and difficult. So, I think there is a recognition by most space actors that we need to come to some sort of agreements on space exploration and resource extraction from various different celestial bodies. All those things will require some kind of agreement.

At the moment, it does not look conducive. That does not mean that it is not possible. If we look back to the Cold War and some arms control agreements, they happened at times of great international tension, so they can be the meetings and the scaffolding upon which you can build better. It sounds a bit naive perhaps, but it can be the scaffolding upon which you can build greater understanding.

I think we will be driven, through the complexity of operations and of the space domain as we go forward, into finding some kind of agreement. I am somewhat hopeful that we will manage at least to move forward from this resolution that the UK has sponsored to something like a more binding treaty, but that might not happen any time soon.

Q18 Stuart Anderson: Do you believe Russia and China would be in that treaty? Would that be acceptable to them?

Dr Hilborne: Well, it would depend on the treaty. I used to work in the UN, and I have seen discussions trying to come to an agreement about what a space weapon is. These are very arcane elements to define; a shadow could be considered a weapon depending on the kind of system you are looking at. Finding that kind of agreement to, say, a really binding arms control treaty might be a step too far, certainly in the near term.

On things like space governance, we are trying to think about the distance, the approaches, how close a satellite can get before they are contravening our general understanding. So, when we see Russia conducting those proximity operations with western satellites, like the US spy satellite recently, we would have a definite binding agreement. Increasingly, that will be something that all parties need to agree to. There will be pressure, just from the complexity of the domain. That in itself is not a binding arms control treaty, but it is a good starting position perhaps for greater restrictive governance in space.

Stuart Anderson: Thank you. It will be interesting to see if the willingness is there internationally as we progress these discussions.

Dr Hilborne: Notably, Russia did not sign up to that agreement, so who knows?



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Stuart Anderson: Interesting times ahead. Dr Presley, is there anything you would like to add?

Dr Presley: To build on what Mark was saying about the UN and whether or not China would buy in to any agreement, I think that is almost a separate question. There is an increasing global consensus that some norms of behaviour should be established in space for the benefit of everybody. I think there would be a willingness of the majority of participants to be involved in that and to develop a more routine way of operating in space that is clear to everybody.

As I mentioned earlier, with space tourism in the headlines at the moment, having humans in space will perhaps accelerate that discussion and bring it to the fore. To actually be able to do anything about that with some sort of awareness of that domain, to understand what is happening, to call out bad behaviours and to deter other people from acting in a non-acceptable way would be part of that discussion.

The final piece to that is that, rather than a very large UN international treaty being the foundation, it could perhaps be built from the bottom up by establishing common regulation and licensing norms. Where the UK has experience as a regulatory country, in the City of London, in insurance and in other areas, applying that regulatory expertise into the space domain and being a country that other nations will want to come to in order to base their operations, will be something that the UK could build on. It is that consensus of norms of behaviour that will form the basis of a more secure space environment, rather than an international treaty, which would be preferable but, being pragmatic, could take many, many years to be realised, if at all. So, a degree of pragmatism is required and building from the bottom up through establishing international norms, through regulation and licensing.

Q19 **Richard Drax:** I want to talk about space situational awareness, which I will shorten to SSA. I am sure I am talking to those who understand, but many people watching may not understand the acronyms. Space situational awareness needs to be an international activity if it is to provide the fullest picture possible. How can the UK ensure that any new SSA capability most effectively contributes to this effort and is interoperable with other providers, both military and commercial?

Dr Presley: It is a subject very close to my heart and it is a key question. It also presents an opportunity for the UK to make a significant contribution to what already exists across the globe in terms of space surveillance awareness, which is the SSA you referred to. In broad terms, SSA talks about the ability to understand what the objects in space are doing.

The defence term of space domain awareness is perhaps one step further than that, in that it also considers the up link and down link to those satellites and the ground infrastructure that contributes to it, so it is a more holistic picture of what is happening in space.



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The UK has a great tradition in this area. RAF Fylingdales became operational in 1963, I think, with the radar upgraded in 1992, and has been operational all that time as a ballistic missile early warning system, but its secondary role has been, and continues to be, space surveillance. It contributes into the US space surveillance network. As a quid pro quo, the UK gets access to all of that network's information within the defence domain and within that security blanket that covers it.

Over that time, the UK has evolved a depth and degree of expertise that has developed over time with some of our personnel over at the Combined Space Operations Center in the US, at 18th Space Control Squadron and with some commercial organisations supporting the military, such as Serco in their analysts up at RAF Fylingdales. So, we have quite a degree of expertise there.

The global coverage of the space domain is achieved by using radars located in various parts of the globe. They will look at various elements of the orbits, as the satellites move around the earth. These are satellites in low earth orbit.

These are satellites in low earth orbit. There are some gaps in the southern hemisphere where we cannot update the track of satellites quite as effectively as we would want to—when I say “we”, I am talking about the international community at large. The UK has access to territory in the southern Atlantic, particularly the Falklands Islands, where, if a space surveillance radar was based there, it would contribute significantly to the overall international space surveillance picture. So there is a contribution that the UK could make.

Pulling that information back to an operational centre, which would use some of the expertise built up over the 50-odd years that we have been involved with space surveillance, would be an overall contribution that the UK could make to that space surveillance contribution. It is something that could be done within a realistic budget—somewhere in the region of tens of millions, I would suggest, for each component, rather than hundreds—*[Inaudible.]* In terms of space surveillance and how the UK can contribute, I think that would be a very tangible contribution that the UK could make. I also think it would amplify the UK voice in the UN and the ambition it has there in terms of establishing norms of behaviour, in that the UK can observe the domain that it is looking to establish those norms of behaviour for, and talk about it with greater authority, thereby amplifying its voice. So I think there is a distinct contribution that the UK can make.

Q20 **Richard Drax:** Dr Hilborne, Dr Presley actually answered the second part of the question, too, in his answer, which was helpful. May I put that to you? What specific approach did the UK take to developing its SSA capability, bearing in mind gaps in existing provision, value for money, and existing national expertise in both the private and public sectors, which your colleague touched on?

Dr Hilborne: The UK, in terms of developing interoperability, has a great advantage, in that it works tightly enmeshed in a number of alliances



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already. Perhaps there are not many other countries that have that kind of capability, or that kind of advantage in terms of already having the Five Eyes and NATO, and the close, particular relationship within that with the US. The UK is already well embedded in those systems. As Mark said, the UK's advantages are things such as having particular territories overseas—there is Diego Garcia, there is Ascension, and there are the Falklands. These can all address gaps. Speaking with colleagues in the United States, these are advantages that they see as quite useful to the wider system. In terms of the costs, these are not necessarily particularly expensive, and we already have the expertise to do those.

In addition, we might argue that a constellation of small sats is something else we can do, and the UK is well set to do that. We have Surrey Satellite, and the basic design for the Canadian system, the Sapphire, is a Surrey Satellite design in low earth orbit—looking upwards, as opposed to looking downwards. There are a number of capabilities, and the UK is already well enmeshed in terms of these systems, so I think we can fit right in. Is that the part of the question you wanted me to answer?

- Q21 **Richard Drax:** That is very helpful; thank you. While I have got you both, it fascinates me that, with all this technology going into space, we are going to rely more and more on it, as our opponents are. Just out of interest, can we be doing more on Mother Earth to provide an effective back-up system, in case what we are essentially trying to provide in space is taken out? That is quite clearly going to be possible.

Dr Hilborne: That is a really important question to think about. There was an interesting study by RAND fairly recently that argued that, even if we were to somehow remove GPS, there are different systems—for instance, in banking and stock markets—that have their own clock system, as the timing aspect is very important to them, and there are back-up systems. We also have other forms of communication masts, cell phones and so on, so there are ways of supplementing that.

One rather more arcane technology would be quantum mechanics, and the UK is currently leading in some of the designs for what is effectively a quantum inertial navigation system. They have trialled that in a submarine. Submarines are required to surface every now and then, because their inertial navigation systems drift after a while, so they have to have a mast above water every now and then, to triangulate the GPS. With the quantum system, the idea is that it is about 1,000 times more accurate and, therefore, the need to surface is much, much less. GPS cannot necessarily get into cities very well and it cannot go underground, so there are perhaps a number of different technologies that we could provide to boost our position navigation and timing capabilities that are not entirely GPS-based. It is certainly one to look at. We already have some capabilities there; none the less, we are very reliant on that currently, and I think we need to think about understanding that reliance. The Blackett report in 2018 by the UK Government made the point that our reliance is profound but our understanding of that level of reliance is minimal. I think an awareness of that is step 1, and thinking about what



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we can have as back-ups is an important element to look at much more closely.

Richard Drax: Dr Presley, I am afraid I have taken the Committee slightly down a rabbit hole, as the Chair referred to at the start. Do you want to briefly add anything to the question I just posed?

Dr Presley: Mark has covered all the key areas very well. Like any good resilience system, you want to look at all sorts of back-ups to make sure you can continue to operate if your primary system fails. Working like that is just part of Defence's culture and history. Space is a really key and interesting question to think about in those terms. How would you operate if you did not have access to some of the space capabilities that we do today? That is very much a worthwhile avenue to explore, rather than a rabbit hole.

Q22 **Mr Jones:** We have already touched on the potential over the next few years for the growth of constellations of satellites in low earth orbit. Clearly, the UK Government have taken the decision to buy into OneWeb. It is not clear what the strategy is for that. I understand from contacts in the MoD that they are a bit cool on the idea of using these. What is your understanding of how these low earth orbit satellite constellations can be used from a defence point of view? Has one been articulated? I have not seen one yet.

Dr Hilborne: Mark may like to start that.

Dr Presley: It is a really interesting question, and one on which I do not have a great deal of further detail to offer. The UK has its Skynet constellation, and Defence is in the process of describing the sixth generation of that satellite constellation, with a budget of between £5 billion and £6 billion. The UK is very much focused on geosynchronous earth orbit satellite communications systems and is very well provided for there. What a low earth constellation such as OneWeb could provide to that is an interesting topic. I do not think that market—whether civil, commercial or defence—has been fully explored yet. It is an area that is developing. If Starlink, OneWeb and the other constellations are to be believed, they definitely see a market for providing fast, mobile broadband across the globe. You can only imagine that that might be of use to the military at some point in some way, but how that will manifest itself, what terminals and receivers will be required and how that would be integrated into the broader defence infrastructure is unclear at the moment.

I do not know that there is a specific answer to your question, other than that Skynet is very well established and operated through Airbus Defence and Space. OneWeb is an interesting capability. How it will be integrated into defence I am not entirely sure at the moment, but it is certainly something I am sure will be considered as an augmentation or addition to its satellite communications.

Q23 **Mr Jones:** It is interesting, Dr Presley, because frankly that is the reply I get everywhere: that no one seems to know what nearly half a billion pounds of taxpayers' money is actually being spent on. So basically, you



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are not aware of any defence elements. I think the MoD were lukewarm, to say the least, about the purchase. Do you find the decision strange to buy into this without it fitting into the broader space strategy, whether defence or commercial?

Dr Presley: On defence's voice in the debate as to whether the UK invest in that, I am not sure where, if or what happened there. It certainly is a capability the UK has now, or a stake in a company that delivers a capability, and it is clear that there are more companies than OneWeb that see a distinct market for this. I do not think that market has been fully realised and described as mature yet. There are a lot of people who think there is a distinct use for broadband in remote areas across the globe provided by low earth orbit constellations. Only time will tell, and I have no view on the viability of that original decision. I do not have access to the rationale or the decision-making logic that went into taking that.

Dr Hilborne: We have seen interest from the US in OneWeb. They have signed a contract with Hughes to provide services for US Air Force research labs and with another similar intermediary for naval and army research labs to provide communications in the northern regions where GEO satellite communications do not work quite so well. So, we have already seen a couple of military contracts signed with OneWeb, but interestingly from the US.

Speaking more broadly, we are starting to see these commercial constellations being used for military activities. SpaceX was recently involved with their starting satellites in US Air Force exercises where data was relayed from an AC-130 to the satellites. There is not a lot of information about what they did or which way the information was going; none the less, they are using that as an intermediary. They are starting to look at communication between the F-35 and F-22, because they do not communicate directly with each other well. Another interesting development is a commercial satellite imagery company called Planet. It started as a small start-up and bought SkySat, which is another low-cost start-up. They signed an agreement with the National Reconnaissance Office in the US for daily imagery between 3 and 5 metre resolution.

We are starting to see more military contracts going to commercial providers. In particular, we have seen this with OneWeb with the US Department of Defense, but it is becoming a broader issue generally and we might find there is more alliance. Where there has been a bit of a hot potato with OneWeb is whether it could act as a positioning, navigation and timing augmentation system, which I think is quite difficult to do, but I am no scientist and cannot tell you if it is or is not possible. I have heard competing arguments. There is nothing to say that cannot work well to augment those that already have SkyNet and have satcom in various different forms and places. That might be something where OneWeb can provide an extra layer of capability.

I have been looking at the Canadian developments and they have something called the unclassified remote sensing situational awareness capability, which is where they tap into different commercial satellite



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systems. They can bring a satellite system on the back of a C-17 into operational areas and use that as a communications node, pulling down information from passing low earth orbit satellites. The more we have of these, the more potential there is for this kind of thing. Again, like Mark I cannot speak particularly on the decision to buy OneWeb and what the strategy was. I am not privy to that particularly.

Q24 Mr Jones: We will wait and see. We ought to ask the MoD questions, Chair, about their involvement in the process and what they see as any potential use from it.

Dr Hilborne, you touched on PNT provision. Where are the gaps at the moment, and what is the most useful contribution that we can make not just to fill those gaps, but for resilience for both us and our allies?

Dr Hilborne: There are none. At the moment in the UK, there isn't necessarily a gap to fill. We have access to GPS. We have lost the encrypted access to Galileo, but we still have access to GPS and GPS III. In that respect, there isn't a fundamental failure there for us.

It is harder to see where we might augment that system, and if we are thinking about benefiting our allies, that's harder again. There are various types of systems. There are low earth orbit constellations which have that capability; the Iridium constellation had that built in at the beginning.

The Japanese system, the Quasi-Zenith Satellite System, is a rather interesting one which, at the moment, is an augmentation system with four satellites. They intend to make that seven satellites, and when they get the full constellation of seven satellites it will be fully autonomous in terms of providing their own PNT for Japan and the local area.

I suppose it depends on what you want the GPS to do. This gives Japan, for instance, a certain sovereign capability. By having satellites effectively overhead, it allows urban valleys to be penetrated by GPS. It has particular applications in Japan, which is highly urbanised. If that sovereignty is something we want, and a bit more resilience, that might be a system to look at.

You might argue that negotiating access to the Galileo system would also give us an extra layer of resilience. Even though it is a very similar system to GPS, having the two could only be beneficial.

Q25 Mr Jones: Do you think the UK should negotiate an access agreement to Galileo?

Dr Hilborne: I suppose it depends on the terms. We do have GPS at the moment. It would be a cost-benefit analysis: what would we get and for how much? It couldn't hurt to have that extra layer of PNT from a separate source so that if GPS is switched off or damaged, we would have another source. If the problem is something like solar weather, both systems would probably go down.

I think that layer of resilience would be handy, but I guess it depends on what it costs. That would be the deciding factor in that cost-benefit



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analysis, but I can't see how it could hurt for us to have access to that if it wasn't too expensive.

Dr Presley: I think Mark has covered a lot of the key areas there. I would say that position, navigation and timing is a major enabler for a whole range of civil and commercial ecosystems—from transport, to agritech, to finance, autonomous vehicles and critical national infrastructure. It is an integral part of the UK infrastructure, and therefore we need to be concerned about it. GPS is there and we have full access to it, which is great.

On the military specific side, should we join the US and Norway in their negotiations for access to the public regulated system of Galileo? I would probably say yes. It gives us a degree of resilience and redundancy, and therefore may be worthwhile, obviously based on the cost of it, which Mark alluded to.

I think that's a good start. The UK is looking at various space-based PNT programmes, through the SBPP at the UK Space Agency. Perhaps augmentation might be a way. Mark touched on the Japanese Quasi-Zenith Satellite System which has enhancement down to centimetre-level augmentation.

There are also other systems we could use to augment it, such as Iridium's low earth orbit signal, or some radio frequency positioning pieces. There's a number of different things we can do, but a lot of them require additional receivers and infrastructure to actually integrate them into the systems, and that comes with a cost as well. A lot of that cost has already been borne and established—to what extent I am not clear, but certainly to some degree with Galileo and the public regulated system. That would probably add to the argument to negotiate access to the public regulated system of Galileo.

So yes, position, navigation and timing, in all its spheres—civil, commercial and in the defence sector—is hugely important to a range of capabilities. It is difficult to think of any piece of equipment that the military have that does not have some sort of input from those sensors on that signal, whether it be timing for communications networks or positional information, which feeds into the navigation ability of a lot of defence capabilities. So it is hugely important and one we should be very concerned about.

Q26 **Chair:** Can I explore OneWeb a bit more? We took a look at this, as we were interested. I think it took people by surprise when the Government decided to purchase this. From a practical, operational perspective, could one of you briefly update us? There are 640 satellites in the constellation. How many are actually launched and working, and where are we with it becoming fully operational?

Dr Hilborne: I am trying to remember the number currently. Mark, do you know? I'm not sure; I think we are about 200 in. I don't think we are quite up to the halfway point. Were you present when we talked about



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some of the military contracts that have been granted to OneWeb recently? The US have signed some contracts with OneWeb for satcomms in the northern hemisphere, particularly the polar region, which is something that they can't do very easily at the moment with GEO and things like Skynet. So we have found some military interests already with OneWeb, but it's not significant necessarily. We have talked about, generally, low earth orbit commercial satellite constellations providing more and more in terms of commercial satellite—

Q27 Chair: Specifically on OneWeb, I was just curious as to where we are, given that the Government now have an interest in it. How close are we to seeing this thing come to fruition?

Dr Hilborne: In terms of the whole constellation, I think, if memory serves me correctly, it's just slightly over 250, so we are almost halfway there in terms of its capabilities. That starts to give us a certain ability—I'm not quite sure how many we have to have before we have a fully functioning OneWeb system. But in terms of your question about military utility, this is something that we have just been discussing; we're not quite sure exactly where that will go at this stage.

Q28 Chair: On Galileo as well, as somebody who watches these things, do you see any frustration that we have not been included in Galileo from a European security perspective?

Dr Hilborne: Yes, I think there is a sense of frustration from the UK that we're no longer part of it. I think they are being very strict on third parties. There were receivers, for instance, on both Ascension and the Falkland Islands for the Galileo system, and when Brexit happened, those were actually removed from those territories, which seems slightly unnecessary. One would think that that is actually quite a boon to the system. There is a lot of British expertise in that system. It is now beyond our control in that respect. So yes, I think there is a great deal of frustration.

Q29 Chair: We now have to buy access to that British expertise, don't we, as a third party?

Dr Hilborne: Exactly. Depending on the kind of contract, that's right: we would have to buy our way back into it.

Q30 Chair: The Government spent £92 million on a study to work out whether we should actually create our own constellation. Did we need £92 million to be spent to work out that we probably don't have the billions required?

Dr Hilborne: I probably couldn't comment on that particularly. It does sound like it's a fairly expensive study—I wouldn't mind a research grant that size.

Q31 Chair: Yes, I'm sure. I have a final point on this, before we turn to space strategy. When we went down to see and visit Skynet, there was something quite profound about the militarisation, if you like, of satellites to protect them from the vulnerability that we spoke about earlier, compared with some of the other commercial satellites that could be fried



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or destroyed in some way. Could you say how many satellites that are, say, geostationary, so at the higher orbit of 40,000 km, and that are of significant size—fridge size and above—are British made? Could you give an indication as to how many we actually have up there?

Dr Hilborne: For GEO, I actually don't know. Mark, do you know that answer?

Dr Presley: I cannot answer that in terms of Skynet other than that it has sufficient slots in the geostationary orbit to be able to provide coverage in the key areas that the UK would normally operate in.

To go back to your OneWeb question, the recent launch of, I think, 36 satellites brought the constellation up to 146. As Mark mentioned, that launch gave access to areas north of 50° north, where the geostationary broadcast is often quite limited. That offers a capability into there. The least I heard about OneWeb was that the overall constellation size was somewhere in the region of 650 satellites, so there is still some way to go. The operationalising of that—the base stations and the antennae necessary to receive that—is still out being beta tested, so exactly how they could be incorporated is yet to be further developed.

Skynet is certainly a well-found broadcast satellite communications capability. What I do know is that geostationary earth orbit slots are very hard to come by—they are almost all occupied. Skynet has access to those really key slots, which gives the UK military some really valuable broadband communications across all the key areas of the globe. Without digging into my notes, I cannot recall the precise numbers other than to say that they are pretty much what we need.

Q32 **Chair:** The reason why I probe this question is that one of the last briefings I had on this subject was that we had hundreds of British-made satellites that we continue to be operationally responsible for, but you could count on one hand the number of satellites that were of military grade that we could actually say were secure and not vulnerable to potential attacks. They were observed, monitored and protected to a level that we could have a much higher degree of confidence. That was a little bit concerning. It led to the question of how we in the UK can perhaps offer to become a locality of secure data where data can be stored without using the international system—the United States and so on, which have accessibility around the world—but a single satellite that can cover the United Kingdom alone, where data can be used, so that countries would want to store data in the UK knowing that it was separate from the other constellation of satellites.

Dr Presley: It is an area I am not particularly aware of, to be quite frank, but I do understand the question. I think this comes back to the own-collaborate-access question that is the core of a lot of the strategy and a lot of the defence positioning: which capabilities need to have sovereign ownership of to give national assurance on access, whether that be in crisis or for the scenario that you painted of independent access to data in an assured way?



To actually launch a geostationary satellite that could achieve that, and to find a slot in that orbit to put it in, could cost many billions of pounds, so it would be required to be put into the balance in terms of what other capabilities we could get for the cost of that particular scenario that you have described of independent assured access to databases in the UK.

Chair: Okay, thank you both. Let us move on to space strategy. I call John Spellar.

- Q33 **John Spellar:** Earlier, you talked about the difficulty of getting various Government Departments not only developing but integrating their strategies on this. In that context, has the delayed publication of the national space strategy been detrimental to developing coherent Government policy, and has it also created difficulty for industry as far as you are aware?

Dr Presley: Mark, do you want to kick off on that one?

Dr Hilborne: The UK has a fairly entrepreneurial space sector that I think is managing quite well without that kind of direction at the moment. I think that something like the national space strategy would add coherence. Where it would probably have the most effect is, as you alluded to, aligning the different Government structures to work closely.

Like I said before, we are all expecting that to happen, but that is a difficult one in that we are looking at commercial, civilian and military elements of the space sector all working and meshing together. That is quite difficult. We have not seen that in other elements. A national space strategy would give us, at least, an end point, but at the same time I suppose we need to think how important that is. How much do we want that to be defined by a singular document?

There are pros and cons. There is certainly some hesitation about inward investment, waiting until companies see what the national space strategy will look like. It is probably having a slight impact. When it comes, it will be useful, but I don't know if it is particularly binary in terms of helpfulness with where we are currently.

- Q34 **John Spellar:** Is it not the case, as is so often, the fact that the questions and answers are difficult does not mean that they become any easier if you delay for a year or two? Government have to grasp that. As we have seen in the pandemic, when real necessity presses, they can pull these things together. I am not saying that we should be gratuitously rushing things, but is it a justifiable concern that the space strategy should really be pulled together so, as you rightly say, Departments know and then start to develop their policies in line with that?

Dr Hilborne: It is certainly a concern that it has been delayed—it has been delayed by many years. You make a good point that things do not necessarily get any easier the more we delay them. In fact, probably in the timeframe that we have been expecting this, we have seen a number of changes in the space sector generally, with various activities becoming much more prevalent. So, it needs to be done, and we will see when it



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comes out exactly how useful it is. But, as a singular document, I am really unsure as to precisely how well it will—*[Inaudible.]*—and how much we need to be guided in a singular fashion. There is a top-down and a bottom-up direction to this, and some of these companies are doing extraordinary things without that kind of direction. Whether that direction will hinder or help, I do not know.

Dr Presley: The national space strategy is much awaited, and people are waiting to see what it comes out with. Naturally, it will be extremely difficult to manage between the competing demands of all the various Departments that will want to have a say, but I sense that industry is awaiting that demand signal from Government to make their strategic decisions and investments more focused in that area.

As for exactly what the strategy should or should not do—crikey—it is a very ambitious document. I think the last policy was 2015, and that sort of came and went without any great impact, as far as I can tell. However, I think that the national space strategy has caught the attention of the moment. There is a focus on space that there has not been before, for the reasons we have talked about.

There is a consensus that we need to do something and to focus on space, but I think everyone is hanging their hat on this national space strategy to meet a lot of those needs. I suspect that, by necessity, it will be an exercise in compromise, to gain agreement across all the various Departments, but it will be really interesting to see it when it does arrive, because it will provide industry with those demand skills.

I hope that we can focus on some particular areas, rather than trying to do a bit of everything. By doing that—trying to do a bit of everything—we dissipate our impact internationally, whereas if we can focus on one or two areas, perhaps we can make a significant contribution that would be more valuable than a dissipated and broad attempt to cover all areas. That is my personal view; exactly what is in the strategy, we will have to wait and see in September, or whenever it is due to be published.

Q35 **Richard Drax:** How can the Government most effectively draw on the expertise of industry and academia in developing its space defence policy and programmes? Should there be an advisory group to feed into the National Space Council?

Dr Hilborne: We have just touched a bit on the idea of a SAGE for space. Although I think the National Space Council is an excellent idea in drawing together a number of divergent needs, some of the more tactical decisions probably need to be fed up to by another layer, so something like a SAGE for space could be quite useful in feeding up to that.

Thinking about UK defence requirements, increasingly we are seeing the military follow a commercial lead, so to some extent we are finding the military is buying certain capabilities off the shelf, or even having, as we mentioned earlier, commercial companies provide that capability, such as



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commercial satellite imagery in the US, for instance. Increasingly, how we bring those together will be an issue.

The US have something called In-Q-Tel, which is a venture capitalist firm that works for the US intelligence community. It keeps an eye on promising developments and invests in them. That is an excellent way of promoting and keeping close contact with some commercial developments and how they might be of use, whether it is intelligence or space. Then the US have DIUX—Defense Innovation Unit Experimental—which is the unit that looks at commercial companies to try to leverage those capabilities for the military. A difficulty that the US have found is that, culturally, places like Silicon Valley don't want to work with the military, so it requires a fair amount of effort to bring those two cogs to mesh. That is no insignificant effort.

Those kinds of things are useful templates for the UK to follow as we look closely at some of the commercial developments to see where defence can draw from them. That tends to be much more cost effective, rather than trying to drive them from the defence sector. That is happening even where there is what we might consider to be a huge budget in the US. The US are increasingly looking at commercial companies for ideas, capabilities and technology. The R&D in space is now mostly commercial, so it is about leveraging that as much as possible.

Dr Presley: To add to that, the SAGE for space concept seems to be gathering pace. I have heard it mentioned on a number of working groups and roundtables that I have been involved with. In doing that, we should not forget that SAGE for space should be about not just the science and technology element of space but some of the broader elements.

For a long time, space has been focused on the technological and technocratic side of things, rather than the broader application of space-enabled capabilities. Therefore, the commercial side should be much more closely integrated into that, as well as the civil side, of course. That is made even more important by the continual blurring of the boundary between defence capability and commercial capability. Most satellites are dual-use. It is indistinguishable in terms of their operations whether they are serving a defence requirement or a commercial requirement. Therefore, bringing those two environments together would be crucial to any advice.

The third part of that triangle is the academic community. They are continuing to make some really innovative moves into the space sector, which they can now afford to do with the reduced size of satellites, the use of commercial, off-the-shelf technology to build satellites, and the falling cost of launching satellites into space. That gives them access to space. A lot of the start-ups that venture capital firms such as Seraphim have taken on have their roots in the academic arena and have been brought into the commercial sphere. Any element of that SAGE for space—any advice, any leveraging of the commercial—can only be the natural way forward for not only defence but the UK as a whole.



The final piece in that jigsaw is perhaps a SAGE for space, but also having that operational focus for space. The Chairman mentioned his visit to Skynet and seeing the operations room there. He said how impressed he was. Having access to that visible, open and transparent understanding of the space environment through an operations centre would provide a focus on a lot of the issues that we have talked about today and enable those issues to be brought out into the open and resolved—or, if not resolved, at least tackled in a more coherent and holistic way across the three environments of Government, academia and industry.

In answer to your question whether commerce and academia can be used, they absolutely can. They are key to a future defence capability that can leverage off capabilities across all three sectors.

Q36 Sarah Atherton: Can I ask for your opinions, please, on what challenges you think the MoD faces in recruiting, developing and retaining space specialists? To put it in context, we have the UK Space Command, which I understand is growing in numbers rapidly, and we have the space academy to train specialists and which I am reliably informed is not a very glamorous environment. We also have the space campus in Harwell, in Oxford. What challenges do you think the MoD is going to face, given what we have already?

Dr Hilborne: That is an excellent question. Up until recently, space has not been a career track in the MoD or the RAF. It has been something that people might do for a year or two before going back into flight operations or something else. For the MoD, having a proper cadre and career track is particularly important in making sure that we get that expertise in and that we keep that expertise.

As the last question identified, there is such an overlap now with elements in the commercial space sector that we will need also to think about new ways of recruiting people and allowing a more porous barrier between the commercial side and the military side—bringing expertise into the military. There are moves afoot in the UK and the MoD to do that. The US is a step or two ahead. They have looked at all sorts of things, like changing from a legacy retirement system to a more blended retirement system, in which people can move in and out of the military and they do not have to serve the full 20 years before they get the full military pension.

Having a system that will allow people to enter, exit and come back in again is important. That is a cultural issue as much as anything else. If you bring in someone, say, at OF-5 level, it can be quite difficult if they have not been through officer training or had superior command. There are a number of cultural elements that need to be considered there.

Alongside this, there is also Project Astra, with the RAF looking at becoming a kind of digital service. Again, that is going to be a cultural and organisational change as much as anything—looking at recruitment through a number of different lenses rather than as traditional military recruitment. As warfare becomes more information based, how we bring people in will be quite different; their backgrounds will be quite different.



That needs to be identified. The challenge is as much cultural as anything else, as we move to a much more informationalised and digitised battle space. That is true of space, that is true of the cyber domain and that is true more broadly.

Those are some key elements. Things like artificial intelligence and machine learning will require, again, those kinds of specialists to pull a lot of that together. We are starting to see movements in that direction, but it probably needs to accelerate. We want to bring those people in and keep them there.

Q37 Sarah Atherton: You mentioned cultural challenges. How long do you think it will be before we have a woman on the moon? We'll have a sweepstake.

Dr Hilborne: Hopefully soon.

Dr Presley: On the people question, certainly in Space Command—my connection broke right at the end of your question, but I think I picked up the essence of it from Mark's answer—he, working in the space academy, is very much closer to this than I am. Sorry, I said "space academy"—that was a Freudian slip; I meant Defence Academy. Perhaps there will be a space academy—who knows?

That cultural question is a key one. Having a career path for people who join the services that would flow through the space element, and perhaps out the other side, covering all the different areas of defence capability, is going to be key, so that people who want to be involved in space can do so without potentially jeopardising their access to the most senior levels of all three services.

That is a cultural shift that will need to take place, as well as a structural and process one, in terms of the careers of people in the military. To enhance that culture, we are now seeing that we have change initiators in the space directorate and in the commander of Space Command, so people can see a focus for space in that respect.

Space also needs to be part of the broader professional military education, not just a space academy or a geek school where people go and do space stuff. It needs to be integrated into the whole defence piece. That subject needs to be involved with all levels of military education—again, not just at the technical, engineering level but more broadly in terms of understanding the commercial use of space-enabled capabilities, because of the dual nature of a lot of satellites.

So, it is much broader than the technical understanding of space or the orbital dynamics of satellites, what they can do and how they do it. It is how that is integrated into the overall infrastructure of a state and how that relates to other nations as well. It is a strategy and a policy, the links between policy and acquisition, and that link between industry and how a nation can drive that.

Space is not just a defence question anymore. It is question that is more



national in outlook, which makes it different from the other environments. What I have heard from Space Command and from Goddard is that there is significant interest to come over to Space Command and enjoy the new venture that has started. I think that is a very exciting initiative and hopefully it will go far.

Q38 Chair: Just a couple of questions to wrap up. Going back to the geopolitical situation and the interaction between China and Russia on space, from a military perspective we are seeing them change their doctrine to include space strategy as well. Can you comment on that? Is there any alignment in how they are operating? Are they moving closer together?

Dr Hilborne: They are. I don't know precisely how. The two states don't necessarily make great allies, so I think we will have to wait and see precisely how closely they might align on some of these projects. We have seen the collaborative potential venture for a lunar base, for instance.

We are starting to see some alignment but, from what I understand, Russia is always slightly cautious of China and of getting too closely aligned. We look cautiously at China. We have to remember that China has probably wanted to do exactly the same things in space that we are doing. We often hear the term "space race" but we have to be very cautious how we apply that.

China is making great strides. It is now the dominant player of the two states. A lot of Chinese technology has Russian DNA in it, but China is definitely the dominant player of the two. I am cautious as to what kind of predictions we can make about the two working closely together in the future, but it is certainly something to be concerned about.

Q39 Chair: Could you rate the four big systems— GLONASS, BeiDou, which is the Chinese system, GPS and Galileo? If you take GPS as being the Rolls-Royce, where would the others sit?

Dr Hilborne: Galileo is an extremely capable system. GPS III will be very similar. I think the latest version of GPS III and Galileo will be similar, so the two are quite similar in terms of their capability.

We have seen the BeiDou system grow from a national to a regional to a global system. It is different in that it is a two-way system, whereas the others are a one-way system. That may or may not be useful; we will see as time goes on what that might offer.

They all offer—GLONASS as well—similar levels of resolution. We will probably find that we will go through different iterations of them. In terms of resolution—

Q40 Chair: Is the Russian one global or just regional? India have a regional one as well. Is the Russian one global?

Dr Hilborne: Yes, the Russian system is global. India has a regional one that we talked a bit about before. Japan has a very specific system that is



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national, but slightly regional. So, yes, it is also an international system. They all offer extremely good, accurate resolution and information.

Chair: Dr Presley, any comment on that?

Dr Presley: I was just interested that GPS was described as a Rolls-Royce rather than a Lincoln Continental or something like that.

Q41 **Chair:** I was actually going to take you around the Monopoly board. If it were Bond Street, where would the others be around the Monopoly board? Would they be Mayfair or Old Kent Road? I thought that was a bit far for this late stage in the day.

On a lighter or more serious note, Sarah asked when we are going to see a woman on the moon. What language will be the first language spoken on Mars?

Dr Hilborne: I am not Mystic Meg, but I am fairly certain it will be English.

Q42 **Chair:** Really? Not Chinese?

Dr Hilborne: English, I think. Whether it is commercial or national will be another question, maybe.

Chair: That will be one to watch. Sirs, may I say thank you very much indeed, Dr Mark Hilborne and Dr Mark Presley, for your time this afternoon? It was a fascinating introduction for the Committee to look at this important and growing area. On behalf of the Committee, thank you for your time.