



UK Engagement with Space Committee

Corrected oral evidence

Monday 28 April 2025

3.45 pm

Watch the meeting

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

Evidence Session No. 10

Heard in Public

Questions 98 – 104

Witness

[I](#): Major Tim Peake CMG, British astronaut, European Space Agency.

Examination of witness

Major Tim Peake.

Q98 **The Chair:** I begin by welcoming Major Tim Peake, who is well known to everybody listening and watching, but especially to this committee. We are absolutely delighted that you are able to join us today for this session as part of the work of the House of Lords Committee on the UK's engagement with space. Thank you so much for being with us. I will explain the format: a number of us will ask questions and people will dive in with extra, supplementary ones. It will be an interesting and lively hour, I hope.

I will begin with the first question. We would love to hear some reflections on your experience as a UK astronaut and how this has shaped your thinking on the future of space and the UK's role within it.

Major Tim Peake: I thank the committee for inviting me to give evidence to this inquiry. That is a really interesting question. It might help to consider how the landscape has changed since I was selected as an astronaut by the European Space Agency in 2009, which is when I became a lot closer to the space sector. In 2009 we did not have a UK space agency; we had a British National Space Centre, which was more of a co-ordinating role than a delivery role. It had been 18 years since Helen Sharman first flew to the Mir space station as a commercially funded enterprise. The UK was still not investing in human spaceflight in 2009. In fact, when I joined ESA I was the reserve astronaut and forecast to fly in 2021. To put it into context as to what was happening in space, we had about 900 satellites up there and it cost \$54,000 a kilogram to fly into low earth orbit.

Fast-forward to today and we have a well-established UK Space Agency, with about 450 employees managing a budget of £618 million a year and about 10% of the UK's ESA budget is invested in human spaceflight. We secured a long-duration mission to the space station in 2015. We now have four astronauts who have been selected by ESA and are eligible to be assigned to space missions and, yes, I am including myself among those four. Of course, we also have the ESA site at Harwell, ECSAT, which is well established. In terms of satellites, we have gone from 900 to about 13,500 satellites in orbit now. In terms of cost, we have gone from \$54,000 down to about \$1,400 on a Falcon Heavy to get one kilogram into low earth orbit. So, over the past 16 years, it has been incredible to watch this exponential growth in the space sector.

As astronauts, we are very privileged because we get to touch some experiments at first hand on board the International Space Station. I know many experts in their own field have given evidence to this committee, such as Katie King from BioOrbit, who spoke about protein crystal growth. When you are running those experiments on board the space station, it is a huge privilege and a real honour to be there and you appreciate the importance of what you are doing; for example, for the pharmaceutical industry. Protein crystal growths can allow

pharmaceutical companies to make drugs which are far more effective and efficient, meaning lower dosages for patients and therefore lower side-effects. Making metal alloys is another example. There is an incredible electromagnetic levitator on board the space station, which is a wonderful payload and is able to make metal alloys that you simply cannot make here on earth. They are stronger, lighter and more elastic. Companies such as Rolls-Royce have benefited from this research. We can make engine turbine blades that are lighter and stronger, which means more fuel efficiency so we can make our aircraft have less impact in terms of a carbon footprint. There are manufacturing benefits as well. I know that Space Forge has given evidence to this committee. What is happening with semiconductors right now is incredibly exciting: the purity of the silicon wafers allows our microprocessors to be many times more efficient than they are today, which means they use a vastly reduced amount of energy and there is less thermal output so miniaturisation can go down another order of magnitude. Incredible research is being done.

On the space station I was asked to go to the 3D printer one morning and take out a tool; it was a plastic tool that we needed for an upcoming spacewalk. That was in 2016. Today, we are not printing plastic tools; we are printing human organs using bio-ink, which is phenomenal. Of course, the future potential is to print a human heart for a patient who needs a transplant, for example, not to mention things such as water purification systems on board which have spin-offs to the benefit of people back here on earth. There is food security. As an astronaut, I never thought I would be having lessons on how much you can stress a lettuce in space but there are huge benefits that carrying out that work can have for our food security here on earth. From a personal point of view, we are invested in the life sciences. I did about 23 life science experiments investigating the changes to my human body, which will help with the ageing process and of course the demographics of an ageing population here on earth.

As an astronaut, when I am asked "Why space?" I tend to go to three pillars: science, inspiration and exploration. In terms of science, these are the things that directly improve our life on earth, such as healthcare, energy and climate resilience, manufacturing new technologies and, as I have mentioned, food security. Most of this will ultimately lead to economic growth.

Inspiration is sometimes a bit harder to quantify—it is a bit like the Apollo effect for the United States—but we know that the inspiration factor will result in a greater number of our younger population taking up STEM subjects and then benefiting the economy in that respect. Just yesterday I was at Windsor Castle with the Scouts as a Scout ambassador. We had hundreds of Scouts who were receiving their King's and Queen's Scout Awards. We introduced the space badge for the Explorer Scouts—the older group of Scouts—earlier this year and already 108,000 Scouts have completed their space badge, which goes to show that space has an enormous capacity to be able to inspire our younger generation and we should not underestimate the positive impact that can have on society.

The third pillar is exploration. This is the understanding of our place in the universe and the new discoveries that we can make, such as investigating exoplanets, dark matter and possible life on other planets. So, when I talk about why space, those are my three pillars that I think about.

I want briefly to touch on the cost of access to space; I gave you some figures on it. The new space economy that we often talk about is being underpinned by this vast reduction in the cost of getting to space. Things that we thought were science fiction 10 years ago were science fiction not because of insurmountable technology hurdles but because of the prohibitive cost of access to space. In 2023, the European Space Agency did a SOLARIS study on space-based solar power. I spoke to the author of that report, who told me that once the cost of access to space drops below \$1,000 per kilogram, space-based solar power becomes economically viable. We are very close to that figure right now. The prospect of the SpaceX heavy lift rocket Starship becoming operational could take the cost of access to space down to \$200 to \$300 per kilogram, maybe even less. So there are incredibly exciting prospects for things such as space-based solar power in the future.

The follow-on questions will allow me to get to the second part of your question, which is the UK's role in the future of space so I will leave that for then.

We are in a new golden era of space exploration with vast potential for benefits to society. I know this committee has already heard about the McKinsey report and the estimated \$1.8 trillion global space economy by 2030. From a purely economic point of view, the UK is well placed to take advantage of this growing sector but the window of opportunity for establishing ourselves in a leadership role to take advantage of that first mover scenario is narrowing very quickly. The decisions that we make in the very near future will decide whether the UK becomes a first-tier nation that is competitive in space or whether we end up playing a more supportive role, with just niche industries in that sector. Sorry, that was a rather long answer to your first question.

The Chair: That was terrific: a great way to open up things we want to talk about and indeed, builds very much on some of the evidence we have been getting. Lord St John has a follow-up question that he wants to ask.

Lord St John of Bletso: Yes, I have a cheeky question to ask of you. We are in the golden era of space exploration, but NASA sent two astronauts, Butch Wilmore and Suni Williams, to space and they were up there for nine months. You were there for six months. What does this do to the human body? If we are talking potentially about space tourism in the future and the huge opportunities, I am intrigued to hear from you how they survived. What it does to the human body is extraordinary. Could you possibly give us your insight?

Baroness Bonham-Carter of Yarnbury: And Butch is not young.

Lord St John of Bletso: No, he is not.

Major Tim Peake: In fact, a good friend of mine, NASA astronaut Don Pettit, has just landed after over 200 days in space at 70 years old.

Baroness Bonham-Carter of Yarnbury: Like some Lords.

Major Tim Peake: We are becoming much more knowledgeable about the impacts of long-duration spaceflight on the human body. Ultimately, your body goes through a rapid ageing process. We know that your bone density and your muscles will atrophy and we have learned how we can use countermeasures such as exercise to prevent that from happening. We do high-intensity exercises for about an hour and a half each day on the space station. Loading the skeleton and getting that muscle/skeleton interaction really helps to reduce the bone density and muscle mass loss.

There are other changes as well: your microbiome changes, your immune system becomes depleted, your eyesight changes, your arterial system changes and your skin ages. There are lots of changes which make an incredible environment for studying the ageing process because, in effect, you are taking fit, healthy individuals and studying the ageing process in a short period of time. The human body's ability to adapt is quite remarkable. It adapts both to microgravity—quite quickly, actually—then it adapts back to gravity when you come back to earth. That can sometimes be uncomfortable for the first couple of days. It takes about two months to recover from a six-month mission to space, but ultimately we make a full recovery. We have now had several astronauts who have spent nearly a year or just over a year in space and of course we are studying the impacts there.

Lord Shamash: Can I just ask you to very quickly, for the benefit of the committee, give an idea of the size of the space station? We were talking earlier and you described it as the size of a Boeing 747; I was absolutely flabbergasted it was as big as that.

Major Tim Peake: There are 16 pressurised modules of the space station and that combined volume is about the size of a 747 jumbo jet, so there is plenty of room for seven astronauts on board. When you include the truss section, which is the solar panels and all the equipment that keeps the space station running, the entire space station is about the size of a football pitch, so about 400 tonnes of hardware; it is a big space station. The first two modules have been up there since 1998, and it has expanded since then, clearly. It was originally due to retire in 2015 but has been extended to about 2030.

Q99 **Lord Clement-Jones:** I want to talk to you about the UK expenditure on space. You mentioned the figure of something like £618 million for the UK Space Agency. The National Audit Office has found collecting all the pots from which money comes quite difficult: UKRI, Defra and probably other sources of funding, including spending on the European Space Agency. Do you think the level of public investment and policy attention to space in the UK is adequate? Can we seize the opportunities that exist without

greater funding and focus?

Major Tim Peake: When you talk about funding it is important to think about what the outcome is: what do we want to achieve to be able to ascertain whether that funding is sufficient? I have read that the UK spends about 0.05% of its GDP on space, which is significantly less than our European peers. It is about three times that much in terms of a percentage of GDP in Germany, France and Italy. So, if we are looking for a leadership role in space, especially in those areas where we have current expertise, and if we want to compete as a first-tier nation in space, it is clear that our current levels of funding are not sufficient to fully seize the strategic opportunities that the current space sector offers. I have heard among my European Space Agency peers that the UK punches above its weight in terms of its rather modest investment. Actually, it is probably not punching above its weight but punching below its potential when you think about our incredibly strong industrial sector, our academic excellence and our scientific talent.

In terms of what we want to achieve with that money, I thought the *Space Industrial Plan* outlined quite well the five goals taken from the national space strategy that will be the focus out to 2030. Those goals are: space domain awareness; in-orbit assembly, servicing and manufacturing; space data for earth applications; position navigation and timing; and SATCOM technology. These are areas where the UK has clear strengths and so this is where we should be expecting to take a leadership role. But if we are to take a leadership role in those five areas, the current levels of funding are not sufficient.

The second part of your question was about policy attention. There has been some great work about policy attention over the last few years in terms of producing a national space strategy and a defence space strategy, and then following up with the national space strategy in action and the space industrial plan. That has really helped to give clarity and direction and prioritise those 22 goals in the national space strategy down to the five goals that we really want to focus on. The challenge with that policy attention is that space touches every department. It is hard to think of a department that is not touched by the space sector in some way, not just across Whitehall but the MoD, the CAA, the UK Space Agency and the UK research institution. Clearly, in addition to the policy papers that are written, it is really important that we have better communication and better co-ordination across Whitehall and with these agencies in order to have a coherent space policy.

In July 2023 I was invited to the National Space Council meeting, which was incredibly productive. There has not been another meeting since, but I was encouraged. I listened to the evidence that Minister Bryant gave to this committee, with a clearly renewed, strong focus on having coherence and communication across Whitehall, which is a very important point.

The Chair: Just to clarify for the people listening, it was a joint meeting with the Scottish Affairs Committee and the Commons that Minister Bryant attended last week. Not everyone here was represented but those

of us who would certainly agree with that.

Lord Clement-Jones: Just to follow up on my question, what would be the right amount of spending?

Chair: An easy question!

Major Tim Peake: I am not sure that I am the right person to pull out a figure, but we clearly need to be competing. I mentioned a window of opportunity to maintain our position as a first-tier space nation and continue that excellence and leadership role. If we are not investing the same levels as our peers, we clearly will not be getting the same return on our investment. I am not talking about the United States, of course—that is another order of magnitude in terms of its investment—but certainly in terms of our European peers.

Lord Shamash: Germany, for instance.

Lord Clement-Jones: Germany and France.

Major Tim Peake: Absolutely.

Q100 **Baroness Stowell of Beeston:** Thanks for being here, Major Peake. You have touched on what I want to ask you already, which is about the national space strategy. Some witnesses that we have heard from over the last few weeks have argued that it is a bit too wide in what it is trying to cover but we have not heard much from witnesses as to where the UK should be focusing its energy.

You have just talked about the space industrial plan and those areas, but I noticed that when you gave evidence to a Commons committee in 2021, one of the things that you said then was that the 2021 national space strategy was lacking clarity on how it would achieve its goals. Could you tell us where, in your view, the UK should be focusing from what was outlined in the national space strategy? What are the areas that we might work more collaboratively on with other nations rather than just relying on our own steam to succeed? Could you just expand a bit on that?

Major Tim Peake: The key is to think about what we want to achieve in terms of sovereign capability and collaboration with other partners. I mentioned the space industrial plan and the five goals that are being set out. I broadly agree with the space industrial plan as a strategy moving forward. From a government point of view, the Government can help focus attention by providing the clear demand signal that is required and the long-term funding and stability, because space programmes are not things that you can do in the short term. So long-term stability and funding with a clear demand signal are very important. Strong industrial incentives are also needed; for example, by becoming the anchor customer to SMEs as opposed to just issuing grants in terms of contract awards. So that is a general picture of what can help.

I will dig a bit more into your question and pick out some areas of the space industrial plan that I am very excited about. Space domain

awareness is one of those areas. When we think about space domain awareness, it is easy to think that it is about tracking debris, tracking satellites and being aware of what is happening in space, but it is more than that: it is also about the regulatory framework of space, where the UK is incredibly well placed to play a leading role. We have a strong legal and financial framework in the UK, so we could become a global hub for space insurance, finance and regulation.

In addition to the leadership role, we can help to steer organisations, such as the United Nations, in developing an operational framework for working in space. If you think about the space environment, about 98% of our satellites do not have insurance and there is very limited regulation and licensing in terms of operating in space. You would not go driving on the motorway if 98% of the cars did not have insurance and could not get out of the way of other cars; it would be a very dangerous place to operate. So having an operating framework in space from a trusted nation such as the UK with a very strong legal and financial sector providing that regulatory operating framework and having a voice within the United Nations that can help steer would be incredibly useful. There is already great work being done by the Earth Space Sustainability Initiative—ESSI—in driving this forward. So, for relatively low levels of funding, that is an area where we can have a huge impact on the global stage in terms of the space sector.

The other area I want to touch on is in-orbit manufacturing, which is very exciting. I have mentioned Space Forge already. Real estate in space is going to be very valuable, not just for microgravity research for our science sector, but in terms of manufacturing, communications and data. One area we need to look at very carefully is how we access microgravity once the space station retires in 2030, which is not that far away. Where is our scientific community doing its microgravity research and where are our commercial companies able to engage in microgravity research? There are a number of proposals for a follow-on station when the space station retires; two of the most advanced are from Axiom Station and Vast with Haven. I should point out for transparency that I am currently working with Axiom Space as a strategic adviser. Axiom Space is not just looking at building the next space station, it is providing spacesuits to NASA for the Artemis programme and looking at orbital data centres, which is another really interesting and exciting area.

We talk about space data for earth, which is one of the five goals in the industrial plan, but we should think about data more broadly. It is not just space data for earth—although we get about 60% of our climate data from space—it is space data, full stop. By using a constellation such as the Kepler constellation optical communication system, we can start to think about orbital data centres in space. The current energy consumption by our terrestrial data centres is absolutely huge. Some forecast that about 10% of the United States' energy consumption by 2030 will be going to data centres, and not only are they consuming vast amounts of energy, they are producing vast amounts of heat. Space has limitless clean, free energy and a limitless ability to have thermal

rejection. When that cost of access to space comes down again, we can start thinking about the trillion-dollar market in the mid-2030s and moving our data centres into low earth orbit. The UK is very well positioned to take advantage of these upcoming markets due to our expertise in satellite manufacturing and communications. In addition to these five goals, we should not become too narrowly focused; we should maintain our horizon scanning so that we are constantly thinking about the potential for these new technologies and what we can do. Those are the sovereign capabilities which I am excited about.

In terms of the partnerships and the global collaborations which—

Baroness Stowell of Beeston: Just before you get into partnerships, you have not said anything about sovereign launch capability.

Major Tim Peake: Sorry, I did not mention that. It is in the industrial plan as an existing technology. We take it for granted as something we are already doing but you are absolutely right, it is incredibly important. We will see sovereign launch from Scotland this year, I hope. It gives us that end-to-end capability in the UK, where we take our expertise in small satellite manufacturing and are then able to provide in-orbit facilities and in-orbit launch and operating services backed up by this regulatory framework. So it positions the UK very well indeed to have that sovereign launch capability, not just for small satellites and commercial but, of course, for national security and economic growth. Sorry, not mentioning that was an oversight. I sometimes take it for granted because it is not so much horizon scanning as it is here happening very quickly; it is incredibly important for our economy.

There are then areas where we collaborate, which are, clearly, where one nation cannot do something alone, such as the very complex, expensive missions, the deep space missions, the science, the James Webb Space Telescope, the Artemis programme, the Lunar Gateway, and human spaceflight. These kinds of programmes need collaboration, but we can still have a very active role in those programmes. It is really exciting that we now have four astronauts, including myself, being selected by ESA: Rosemary Coogan, who has graduated from her basic training as a full-time career astronaut with the European Space Agency; John McFall, who has recently passed his medical clearance for long-duration spaceflight as the first para-astronaut; and Meganne Christian, who is working with the UK Space Agency as a reserve astronaut. Human spaceflight missions being part of the Artemis programme gives us the ability to not only have the inspiration pillar that I was talking about earlier, but it allows us to participate in these longer-term, very complex programmes which can offer the UK a huge return on the investment there.

Baroness Mobarik: Do you have any ideas around having a focus on the UK becoming excellent in space launch; for example, in the launch of small-scale satellites? I know in Scotland we have the SaxaVord Spaceport, which has just been completed, but I do not know how successful it has been in terms of launching from there at the moment. We had a second site in Sutherland, which seems to have come to a full

stop although it is very suited for small-scale satellite launch. It seems to me that we are missing a trick. We should perhaps have a cluster of these so that we become the place to go. I do not know what is happening with Cornwall and other sites; you might be able to update us on that. We could be the place for launch. I do not know how much effort is going into that and I would like to hear your views.

Major Tim Peake: You are right; it is very exciting. SaxaVord is the first European launch site to receive a licence for vertical launch, which is on the back of the horizontal launch site that we have in Cornwall. It is exciting and the UK is well placed geographically for polar orbits, which are very interesting for earth observation in a sun-synchronous polar orbit. So, that is an advantage that we have over other landlocked nations, or nations such as Germany, for example, where it is very difficult to launch from without overflying populated areas and the problems that that will entail. So we need to take advantage of that.

To answer your question, we absolutely have the capability to become a centre of excellence for small satellite launches. I do not think that we need to worry about competition from companies such as SpaceX because we are talking about different types of payload and a different type of market: a smaller satellite market offering customers more bespoke operations rather than a rideshare, where you have the risk of not achieving the orbit you wanted to and not launching on the date you want to, albeit at a low cost. So, with the market for small satellites projected to increase to about 60,000 by 2040 from the 13,000 today, there is a huge demand for launch.

Q101 **Lord Shamash:** We have heard a lot of evidence about the UK's relationship with the European Space Agency. What should the future of the UK's relationship with ESA be? Should we take a greater leadership role? Obviously, life has changed a little since Brexit—a word we do not mention—but I just wondered what your take on that was.

Major Tim Peake: Yes, absolutely. The European Space Agency accounts for over 70% of our national space budget at the moment. That is a huge contribution that we make to the European Space Agency; it is a very important partner for us. In terms of financial return on that investment, it is about 9.8:1 in terms of every £1 spent. For that, we get access to those programmes that I mentioned earlier, where we need to collaborate: with larger programmes such as Copernicus, Artemis, Gateway and Earth Observation. Our UK industry benefits from that in terms of geo-return, which is the ESA policy for rewarding contracts for your investment.

It also enables our scientific community to participate in ESA programmes and for us to be able to share that scientific knowledge and have our scientists lead in certain areas. It gives us leverage for our space strategy and a voice at the table at ESA. That in turn helps us to shape European space policy and direct space in a direction that helps our national interests, which is very important for us to do. We have to maintain a very strong relationship with ESA and target leadership in those areas

that I mentioned where we have excellence. I do not think we can expect to lead across all areas with the level of funding that we have available, but we can certainly expect to lead in those areas where we have current excellence.

In terms of return on investment, I was really encouraged to hear Minister Bryant say that our geo-return on funds invested from ESA has gone from 93% to 99%. That is up with our European peers, where we should be, so it was very encouraging to hear that we are getting that kind of return. But, clearly, our contributions to ESA do not come without risks. We need to appreciate the risks in that and be able to balance our contribution with those areas that we want to focus on in terms of sovereign capability and where we need to benefit from international collaboration.

Lord Tarassenko: Baroness Stowell has already mentioned the evidence that you gave in December 2021 to the House of Commons Defence Committee. In that, you said, and I will quote exactly, that, “in an ideal world, the UK would still be part of the Galileo project, having invested a huge amount of money” and expertise into it. We are back as a full participating state in Copernicus as of January 2024. Do you think we should also push to be back into Galileo?

Major Tim Peake: I do. We have a huge amount of expertise. PNT services, and redundancy in PNT services, are part of our critical national infrastructure in terms of our security as well, so they are very important for us. PNT is also very expensive. Whether OneWeb will ever have the capability to give us redundant PNT services is a question I am not qualified to answer, but that is certainly something that could be explored as well. Securing some form of access to PNT is absolutely vital for us in terms of our national security, so we should certainly enter into those discussions and look at what could be possible.

Q102 **The Chair:** I am going to ask you the next question, which is something I am particularly interested in. We have to think about how to position ourselves internationally when it comes to space. The geopolitical situation is constantly changing, the world moves on and space cannot escape the realities that are earthbound in terms of the politics of it. When you think beyond ESA, which you have talked about, where do you think the partnerships of the future might be? Which are the countries that you think of as being not just partners for today but potentially for tomorrow? What areas should we perhaps be thinking about?

Major Tim Peake: Beyond ESA, which I have mentioned plenty as being a strong partner, clearly we have a strong partnership with the United States in operating with NASA, and our MoD relationship with the US Space Force is a very warm relationship that needs to be continued.

Beyond ESA and NASA, in terms of Australia, Canada and Japan, these are countries that have high-tech areas as well and are aligned with our thinking and strategic interests. They are part of the Five Eyes community and would be obvious partners in space as well. But we

should also look at some new, emerging sectors in space, such as the Middle East. The United Arab Emirates and south-east Asia are new, upcoming, high-tech markets and have very interesting and active space programmes. Partnerships there could be very interesting in terms of the lunar exploration programme, for example, and going on to Mars.

On other partnerships beyond just nations, I mentioned before our partnership with the United Nations, which we should continue to foster. We have the ability to project our soft power there, to shape global space policy and to help provide some sort of regulatory operating framework so that we can all utilise space safely.

The Chair: What about European countries beyond ESA? There is a lot of work going on between Italy and the UK, for example.

Major Tim Peake: Italy and Norway as well—there are some very interesting partnerships. What we are finding with this new space economy is that every nation is looking at it the same way we are. It is an incredibly rapidly growing market. Where are the advantages to be had? Where can we collaborate and co-operate? When we think about ESA, we should not think about that as the one basket that we put our eggs into; we need to be much cleverer than that and think much more broadly and in a more diverse way.

Baroness Bonham-Carter of Yarnbury: This may be too political a question, but on the one hand you are talking about all these different countries that are becoming interested in space, understandably, and on the other hand you are talking about the UN and our engagement there. Is there a way to make sure that there is an umbrella in the future, considering what we are experiencing?

Major Tim Peake: In terms of how we operate in the space environment? Space has become militarised over the last five to 10 years, much more so than it was in the earlier days of space operations. The United Nations can provide a framework, guidance and advice as to how we operate in space.

The United States-led partnership has become quite fragmented. If you think of the Artemis Accords, about 54 countries have signed up, and then you have China with the International Lunar Research Station, which has about 17 signatories. We have become fragmented and are entering an era where the International Space Station has provided this global hub of collaboration for so many years, which has managed to transcend tensions and geopolitics on the ground. With the retirement of the space station, we are seeing two different directions in exploration. Once we start moving forward in future years into discussing difficult areas—such as resource extraction from the moon—the United Nations will have a very important role to play to help guide that framework as to how we can all operate in space and collaborate under a safe and sustainable framework.

Baroness Bonham-Carter of Yarnbury: Is that ongoing?

Major Tim Peake: It is, and I really think the UK has an incredibly exciting role to play in the Earth Space Sustainability Initiative and providing that legal regulatory framework, with our financial sector controlling markets of space. For example, we have set ourselves up with the ability to offer not just launch licences but operator licences. A UK operating licence can give you access to space domain awareness, finance and insurance, open up markets, and make sure that you adhere to ESG principles. It becomes very attractive when you put that together as a package, and these are the kinds of areas where the UK could really lead.

Q103 **Viscount Stansgate:** My question is about international co-operation, on which you have just touched. At the dawn of the space age, it was a space race between the US and the USSR. Might the Chinese landing humans on the moon have the same effect in the modern era that Sputnik had on the United States in 1957? It was a shock. What effect do you see international co-operation having on the Artemis programme, not just on the moon/Mars plans and projects, but the accords and the 1967 Outer Space Treaty, which remain important? In view of what you have said about the role of the United Nations, can you say a little more about the way in which you think the United Kingdom could shape UN approaches to international space co-operation, which is going to be terribly important in the future?

Major Tim Peake: Yes, in the future it is going to be a much more challenging environment to operate in than previously. Part of that is because we now have our critical national infrastructure in space, which needs to be protected, and many nations are thinking in the same way. We are now talking about militarising space and protecting our space-based assets. How do we operate in that environment? How do we set rules of the road—if you like—for space? How do we prevent nations doing things such as anti-satellite weapons testing, which is incredibly detrimental to the space environment and produces hundreds of thousands of pieces of space debris? What happens in terms of proximity operations? How do we regulate that? These are all areas where the United Nations and the UK can help with this operating framework.

It should not be too difficult. We have the International Civil Aviation Organization. As a pilot since the age of 13, I am very used to following ICAO rules and regulations, and it enables a hot-air balloon or glider pilot to go flying safely, but you would not dare go into the airways with a 747. We have the framework that enables everybody to operate in a safe manner and is regarded across the world as a logical, safe and efficient thing to do.

In the same way, the International Maritime Organization manages our shipping lanes, and everybody agrees that that is a very sensible and safe way to operate in international waters. It should not be too hard to extend that into the space environment and have an operating framework. Looking at real estate in space, which orbits are incredibly valuable? How many satellites do you want to have in any orbit? Should they have the ability to manoeuvre and get out of the way if there is a

conjunction? What orbits might you want to do higher-risk R&D in, and how do you manage that?

On how we move forward, this operating framework is something that is required to protect the space environment and do it sustainably. Earlier this year, I was invited to the Sustainable Markets Initiative, from which King Charles III formed the Terra Carta five years ago, and the Astra Carta two years ago. This has the ability to convene global CEOs from multiple industries who are all interested in operating sustainably. Certainly, from an Astra Carta perspective, we are looking at space sustainability because any company that wants to operate in space wants to do so for many, many years to come and in a safe manner. So it behoves us to come up with this framework that allows us to operate sensibly and safely.

Viscount Stansgate: Are you fairly confident that national tensions between countries in the changing world will not make this more problematic?

Major Tim Peake: National tensions will always be there; I do not think you will ever eliminate that, but it is beholden on everybody to abide by a sensible rules and regulations framework because every country wants to operate in space. They have invested huge amounts of money. If you have a space economy, then, generally speaking, you do not want to see that space economy placed at risk. So, yes, there could be tensions but the one thing that every nation will have is an underlying principle of wanting to protect the environment that it is operating in for their own national interests.

Baroness Mobarik: I wonder whether you could say a little more about the proposed International Lunar Research Station. It seems to me there is quite an eclectic mix of members: Venezuela, Serbia, et cetera. Perhaps you would like to comment on that.

Major Tim Peake: There is an eclectic mix. Actually, I am not hugely knowledgeable on the ILRS itself in terms of its capabilities or partnership, but I know there are 17 signatories to that. At the moment, I would say that the Artemis programme is more advanced but in the next few years we are going to see that gap closing. At some point there could even be parity in terms of timescales for delivering both an Artemis research station at the south pole and the ILRS.

Ultimately, the moon is becoming a very interesting area in terms of research and development. The location on the moon that is the most interesting is where there is water: at the poles. The south pole of the moon offers the ability to use in-situ resources and extract that water for rocket fuel, hydrogen and oxygen, and clearly for creating an atmosphere for astronauts to live in. There is the potential of tensions there as real estate becomes congested on the surface of the moon as well.

The Chair: It is interesting watching these coalitions of the willing come together on space. It points very much to the UN and the potential for

what it could do if it could get the Security Council to agree. Again, that is the classically British role as well. Sorry, I did not mean to take over. Lord Tarassenko, you have a question.

Q104 **Lord Tarassenko:** First, thank you very much because you have been a STEM ambassador for how many years now?

Major Tim Peake: It is eight years now.

Lord Tarassenko: As a former head of the engineering department in a UK university and on behalf of many engineering departments, we would like to thank you because those efforts make a difference. You just mentioned what you have been doing with the Scouts in Windsor. However, one does worry whether the general public fully understand space because what the general public see is fantastic images from the James Webb Space Telescope on the news or the amazing feat of engineering when a first-stage booster of SpaceX comes back to the launchpad, and so on. That is still very much the view of space, from some of what we have been discussing today: satellite imagery for climate change, even the use of satellite imagery in Google Maps; the importance of PNT, which you have mentioned in your evidence; national security and so on. It does not seem that that is getting through. Is that a fair comment? What more can we do, and how much can we do through the UK Space Agency as opposed to just your own efforts?

Major Tim Peake: I would partly agree with that comment. Raising public awareness of what is happening in space is definitely an uphill struggle, but we are starting to succeed and certainly showing signs of that. I will give you an example: in 2020, when Bob Behnken and Doug Hurley launched on SpaceX as the first crewed Dragon mission, it was the most-watched channel on television around the world. It has the ability to capture people's imagination.

Our role is to grab those moments when the media will showcase something that is happening in space and try to use that as a platform to talk about the wider implications. When I talk at outreach events, I find that when people talk about space, they will think "astronaut"; they will not perhaps think "engineer, scientists, artificial intelligence, quantum"—all these different areas that are related to space and that you can get into.

The UK Space Agency has done some great work recently. Going back to Mission Principia, it reached 2 million schoolchildren and about 30 different education outreach programmes. Many of those programmes are still running because we started partnerships with STEM-based organisations, and it is great to see those partnerships continuing to grow. We have seen an uptake in STEM students in the UK, which is very encouraging; about 35% more female students are now taking up STEM subjects as well. There is always more that we can do in raising public awareness about what we are doing in space: the fact that it is a more diverse community now and there are more opportunities available to you than just becoming an astronaut.

One area where the Government could help and need to focus on is taking students, getting them excited and into STEM subjects, and then actually having a full pathway that sees them through to a job. It is that pathway of bringing industry and education closer together so that students can really relate to what they are studying in schools, and industry can reach out and help to shape the skills that schools are providing. That would help to fill the skills gap that we are hearing that industries suffer from.

Lord Tarassenko: If I could just follow up, you mentioned 35% more females doing STEM subjects. Was that correlation or causation with your space ambassador, or was it unrelated?

Major Tim Peake: I do not know exactly what the cause of that was; I would not like the mission to take credit for it. The point is that so many different organisations have been increasing their STEM focus—perhaps that is part of the problem. We have STEM Learning UK, which in one respect is the STEM hub, and many other organisations that are doing great work in STEM. What we perhaps lack is that co-ordinating overview and body that can co-ordinate all the STEM activity, provide that clear pathway, and help with guiding our younger generations, from taking up the STEM subjects through to apprenticeships and undergraduate placements, for example, and ultimately getting a job in the space sector.

Lord St John of Bletso: I would like to ask a supplementary question. You spoke of inspiration as being one of your three key drivers. You have captured the hearts and minds of the nation, particularly the younger generation. How realistic is it that space education will become part of the national curriculum? Looking forward, it is such an exciting area. As a parent of five, a challenge is making your children excited about learning; many children are not.

I have fond memories of 1957 because I was only five months old when Sputnik 1 went into space and Elvis Presley was the most famous singer at the time. But now is certainly an incredibly exciting time for schools to really go and seriously launch education, and not just in schools but universities as well.

Major Tim Peake: Yes, absolutely. Space is part of the national curriculum now at key stage 2 or 3—I will have to check on that. Also exciting are the resources that are available to teachers. ESERO-UK is an organisation in the UK—sponsored by the UK Space Agency—that provides those resources to try to get space into the classroom and the ability for students to interact with space directly from satellite-based data. If you are going from building rockets to actually then analysing earth observation using telemetry that has come from space, that can be incredibly inspirational and exciting for students. There is some great work going on. I always find that when I go to schools and talk, space has that ability to capture people's imagination. Even if they are not going to go into the space industry, it might get them into a scientific field—engineering, for example—which will obviously contribute to our overall economy.

Lord Shamash: There was a fascinating expression you used earlier about space orbits and real estate in space. The problem with real estate is that everybody wants to go to the best house, flat or apartment. Let us call one of the orbits A, which is the best one, but everybody wants to be there. For example, China or Russia would like to go into A, and there is no space for them. Is there a possible tension? How does it actually work? You created this concept, at least in my mind, and I just wonder whether you could expand on whether there is any problem and whether it could cause aggression in the future.

Major Tim Peake: It is something that is going to be of concern in the future. We cannot underestimate how much space there is. Excuse the pun, but it is a big place; as I mentioned, we have about 13,500 satellites and on a busy day, we probably have about 13,500 aircraft in the sky at any one time globally. All our aircraft are trapped in a very thin layer in terms of where they fly, perhaps between 20,000 and 35,000 feet. In space, you can go out to 36,000 kilometres to geostationary, so there is a lot of volume there to absorb the number of satellites. But you are absolutely right: some parts of space are more interesting than others. I mentioned geostationary, which is valuable and limited. If you want to place a satellite over northern Europe in a geostationary orbit, there is a finite amount of volume of space to do that in.

One way of addressing that is by removing defunct satellites. We have some companies in the UK, such as Astroscale and ClearSpace, which are looking at methods of capturing satellites and being able to safely deorbit them. Clearly, that has spin-off technologies that, for example, the Ministry of Defence might be interested in as well. We are looking at the ability of how we keep space clean: one satellite in, one satellite out.

In terms of constellations as well, low earth orbit becomes a very congested place. It is the cheapest and easiest space to get into, but because it is close to earth those satellites are constantly decaying, so they need some method of propulsion to keep them in that orbit and constellation. So, yes, there could definitely be conflict in terms of proximity operations and congested space orbits in the future.

Baroness Bonham-Carter of Yarnbury: This is a bit of a bugbear of mine: we have been talking a lot about STEM, and I very much believe in STEAM. When you think about Steve Jobs and Jony Ive—I am sure this is true about space as well—you must appeal to not just the scientific child but the artistic child. Because we are all of a certain age, we all remember “2001: A Space Odyssey”; I know that was a film, but it was about design as well. Anyway, you have lived in a space station. I am just saying, when you go around and inspire young people, I hope you are not targeting just the scientific child.

Major Tim Peake: Absolutely not, and I should mention that many of those outreach programmes we did in Mission Principia were focused not just on STEM but the arts. We had a literacy competition and a music competition. We were looking at drawing. In fact, I was in London just last week with Nicole Stott, NASA astronaut. She has a Space for Art

Foundation. We had 35,000 children who had submitted their artwork to create a collage that is currently being shown at Piccadilly Circus. It is a very broad range of children that we reach out to, not just the STEM students.

The Chair: Having said that was the last question I now have two more very quick ones. Lord Clement-Jones and then Lord Tarassenko, and then we should stop because the hour is up and the Lord Speaker is looking forward to seeing you next.

Lord Clement-Jones: I have read that very short novel by Samantha Harvey.

Lord Tarassenko: That was going to be my question.

Lord Clement-Jones: I really just wanted to ask you what you thought of it and whether you had read it.

Major Tim Peake: I have read it. In fact, I will be talking with Samantha at the Petworth Literary Festival later this year. I did enjoy it. What was interesting was that as she was writing it, she had the laptop in front of her and it was showing the camera view from the International Space Station.

Lord Clement-Jones: I did wonder how she managed that.

Major Tim Peake: Yes, to try to give her inspiration for getting that perspective that astronauts enjoy from space.

The Chair: Lord Tarassenko, was that your question?

Lord Tarassenko: That was going to be my question. I was going to say it has had an impact both on scientists and people who are not scientists, and that is the power of the novel, in that it has attracted people to space. My wife is a medieval historian and absolutely loved it. She was asking me questions about orbits and never realised that they went around the earth so many times so quickly. It allowed people who would not access space to get into space through a completely different way because of winning the Booker Prize.

Baroness Bonham-Carter of Yarnbury: It is the STEAM thing.

The Chair: You get a sense not only of the interest we have in the scientific and economic side, but the enthusiasm that members of this committee have. The hour is just up, exactly. You have been absolutely fantastic in giving us some fabulous answers and a lot to think about.

Thank you so very much for being with us; it has been an absolute delight. I look forward to staying in touch and seeing you again soon. With that, we will end the broadcast session.