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**HOUSE OF
REPRESENTATIVES**

STANDING COMMITTEE ON INDUSTRY, INNOVATION, SCIENCE
AND RESOURCES

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HOUSE OF REPRESENTATIVES

STANDING COMMITTEE ON INDUSTRY, INNOVATION, SCIENCE AND RESOURCES

Wednesday, 20 February 2019

Members in attendance: Dr Gillespie, Mr Gosling, Mr Joyce, Mr Khalil.

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MURFETT, Mr Anthony, Deputy Head, Australian Space Agency

Committee met at 10:32

CHAIR (Mr Joyce): I now declare open this public briefing for the House Standing Committee on Industry, Innovation, Science and Resources on the Australian space industry. I would like to introduce my colleague Mr Peter Khalil MP, the member for Wills.

Welcome to the briefing and thank you for giving evidence today. The committee appreciates your participation in the discussion on the space industry in Australia. Although the committee does not require you to give evidence under oath, you should understand that this hearing is a formal proceeding of the Commonwealth parliament. Giving false or misleading evidence is a serious matter and may be regarded as a contempt of parliament. It's very important for people to really understand that if you mislead us or don't tell the truth we will follow it up. The discussion today is public and is being recorded by Hansard. It is also being broadcast live. Each organisation is welcome to make an opening statement of approximately five minutes before the committee proceeds to ask questions. Dr Clark, you might want to kick that off.

Dr Clark: Thank you very much, Chair, and thank you for the opportunity to make an opening statement. The Australian Space Agency commenced operations on 1 July 2018, and we set a goal of tripling the size of the Australian space sector to \$12 billion and creating another 20,000 jobs by 2030. We have a clear purpose, which is to transform and grow a respected Australian space industry that also lifts the broader economy and inspires and improves the lives of Australians. We cannot do this without national and international engagement and without making sure that engagement is very strong.

We've had what can be described as a wonderful first eight months since we established, and we're particularly grateful for the support we've received from across the nation. Australians have been very excited and enthusiastic for us, as a country, to take our place in this new world of space. And, as a measure of that, our cumulative reach has been to over 50 million Australians and people overseas, who have seen or heard about the Australian Space Agency. So, clearly, they're hearing or seeing about us more than once.

The Australian government has recently announced that the agency will be located in Adelaide. The agency will be centrestage at the redevelopment of the Royal Adelaide Hospital, which is known locally as Lot Fourteen. This will be a wonderful multimillion dollar redevelopment and it has a goal of a thriving ecosystem with closer links to industry and defence. This location in Adelaide provides a strong base for the Australian Space Agency from which we can grow, and grow our links with the space industry across the nation. To support the agency's national focus, the minister has asked the agency to continue to work with the states and territories to identify future investment opportunities that will accelerate the growth of the sector.

Very quickly, since the agency has started, we've signed four memoranda of understanding with international counterparts: the French space agency, the Canadian Space Agency, the United Kingdom, and, most recently, the United Arab Emirates. These agreements form a framework on which Australia can build strong links internationally and support opportunities for Australian businesses. We've also worked closely with industry to identify areas for investment signalled by the signing of statements of strategic intent with our industry partners, including Airbus, who is represented here today, Nova Systems and SITAEL, with others to follow.

Our charter has been released which details our roles and responsibilities and the governance arrangements to drive the growth of the sector. We have also updated our space law, so our Space Activities Act 1998 has been amended and modernised to support a greater entrepreneurship and make sure that we meet our international

obligations and provide safe operations for space activities. We're engaging across Australia to provide a vision that really inspires future generations to contribute to space activities. We've also just unveiled our brand, which aims to link our 65,000 years of history and our Indigenous connections with space through to our commitment to the nation and into what is an exciting future in space. Our brand is there to remind us to serve our nation. It's to remind us to honour our past and to build the future.

CHAIR: I might just say—because we're on live broadcast—when you talk about the Space Agency, people immediately think of it as sending rockets to the moon or something. Can you give us a brief overview of exactly what the space agency actually does?

Dr Clark: The roles and responsibilities of the agency are outlined in the charter, which is also on our website. First and foremost, it's to provide one door and one voice nationally as we engage internationally. It's to set the civil space strategy. Defence sets the defence strategy and policy for defence, and the agency will set and guide the national civil space strategy and priorities. We will also coordinate nationally, and we have several mechanisms to be able to do that. We have a clear responsibility as well to really inspire the next generation of people who will contribute to the space agency, and also inspire the nation generally. They are some of the roles and responsibilities of the agency.

CHAIR: Once more—and I'm really talking to people who might be watching this and thinking, 'Are we going to build a rocket or something?' is it merely about regulation or does it also incorporate the development of technology which goes into space?

Dr Clark: It's a great question. If you look at our purpose and you think of space, pretty well everything that we do on earth is connected to space. Every time we look at our location on our mobile phones and that little blue dot moves, we sometimes forget that that's connecting backwards and forwards with our GPS systems that we access. When you think of the timing used in banking, when we look at farms and how we operate in remote Australia, we're using satellite imagery. When you look at our maritime jurisdiction, how we communicate in space is a critical node in that communication network across our airspace, across our maritime space and across such a broad country as Australia. So it touches almost every part of Australians' lives in ways that we often forget.

The agency it is really tasked with making sure that our use of space impacts our broader economy and impacts the lives of all Australians and improves the lives of all Australians. So we're talking about not just what happens in space but those connections between space and earth, and we're also talking about how we take what we're doing in Australia and improve what happens in space. So it's quite a broad brief.

CHAIR: Let's continue with the five minute statements.

Mr Drury: Thank you very much, Chair, and I thank you for the opportunity to participate in this roundtable. I look forward to the discussion about a sector for which I've invested a significant part of my career and which I am very, very passionate about. Before addressing LM Australia's space activities, I'd like to acknowledge that, as an entity, Lockheed Martin Australia has had a presence in Australia for the last 70 years. Lockheed Martin Australia is an Australian company that is engaged in research, design, development, integration and sustainment of advanced technology systems, products and services. We employ more than 990 people with a presence in most states and territories.

With regards to space, Lockheed Martin first invested in Australia some 20 years ago, when we commenced development of the Uralla tracking, telemetry and control facility.

CHAIR: Where's that? In whose seat?

Mr Drury: In your seat, Chair.

CHAIR: Oh, hooray!

Mr Drury: Since then, we've managed to build a solid business and, importantly, become an active member of the Australian space community. Lockheed Martin Australia has identified four pillars around which we've established and plan to grow our business. The foundation of these pillars is a focus on being a responsible, proactive and positive contributor to the Australian space community. Specifically, we seek to build capability and capacity in Australia for our projects and service delivery, much of which I cannot discuss today, through our investments in Uralla—assets like Uralla—and through our sharing of technology, as we have demonstrated with the Satellite Based Augmentation System that has demonstrated a significant improvement in the accuracy of navigation signals over the last couple of years.

We also have a proven record with regard to partnering and investing in research and development activities, with over 15 funded R&D arrangements with universities and small to medium enterprises in Australia today—

the highlight being the research and development arrangement we have with Curtin University. We are working together to develop the FireOPAL space situational awareness capability, which, hopefully, will not only meet Australia's needs but meet the needs of the globe.

Our community leadership and involvement is best illustrated through our contributions to the Space Industry Association of Australia, our involvement in the South Australian Space Council and our participation in numerous seminars and conferences, like the inaugural Australian Space Industry Conference to be held on Monday next week in Avalon and which we're very proud to be involved with.

CHAIR: In Avalon?

Mr Drury: Yes, I'm actually in Melbourne on Monday.

CHAIR: In Melbourne.

Mr Drury: Actually at the exhibition centre.

CHAIR: Avalon?

Mr Drury: Yes. On Tuesday at Avalon and Melbourne on Monday. It's a two-day event.

CHAIR: I thought you said Adelong—it's a little goldmining town! That would be very exciting for them!

Mr Drury: It would have been! Finally, we're also investing in Australia's future workforce, which we think is particularly important, through our sponsorship and support of the National Youth Science Forum, the Australian Youth Aerospace Association and the Victorian Space Science Education Centre, located at Strathmore Secondary College, near Melbourne.

Mr KHALIL: It's in my electorate.

CHAIR: So you can't say that—

Mr KHALIL: I've visited that; it's very good.

Mr Drury: Overall, whilst we are proud of our achievements, there's still much to be done and there are many challenges ahead. These are exciting times, but what I can assure you is that LM will continue to be part of the Australian space community and, hopefully, meet those challenges. Thank you.

CHAIR: Thank you very much for that. Does the University of New South Wales want to—

Prof. Boyce: Yes, thank you, Chair. UNSW, broadly—both the campuses in Sydney and Canberra—has a significant amount of space activity, and we've had that for many years. UNSW Canberra, in particular, has the largest collection of space engineering and science in the country. We've got a team of about 50 people and we call ourselves UNSW Canberra Space. We started from a clean sheet of paper about five years ago. We've been investing internal funds and, more recently, Department of Defence funds to do science; to support the space situational awareness capabilities and developments of Defence; and to develop miniature spacecraft missions, helping Defence explore the art of the possible. Through all of that, we have developed as the trusted partner for space capability development in the small space area for—

CHAIR: Things like scramjets and minor satellites, like the three-kilogram satellites—stuff like that?

Prof. Boyce: The small satellites, yes. Scramjets were actually in my previous lifetime—

CHAIR: At the University of Queensland.

Prof. Boyce: That's correct.

CHAIR: I knew that. I was just making sure they did!

Prof. Boyce: What we do at University of New South Wales Canberra is the science to support development of technology for space to, in turn, receive data in space, convert it to information and get it to the users. As part of that, we are rapidly extending from space technology into the realm of artificial intelligence because we see that as a significant part of the future for space globally, and as one of those niche areas for Australia to embrace and take world leadership in.

We're very good at AI in Australia. We're very good at autonomous systems and we're very good at space, and so there's an opportunity to bring those together. That, in turn, forms a significant part of the work that will be performed in the SmartSat Cooperative Research Centre—smart satellites—if that is funded this year. Our group will lead the advanced satellite systems and intelligence part of that program, if it is funded. So that's the R&D.

We do a large amount of space education on our campus, particularly for Defence but also at the master's program level for anybody who wants to come. We're starting to extend that into undergraduate space engineering, and as part of that we are teaching both civilians and Defence personnel. We have on our campus a national asset facility, the Australian National Concurrent Design Facility, which was established with the

assistance of the French space agency, CNES. We have quite a close relationship with them. That's a facility in which conceptual designs are tested and explored so that the feasibility of a space mission to meet Australian needs can be understood and understood very quickly so that wise investments are made.

Finally, UNSW Canberra is a provider of thought leadership in the country. We were a major contributor to the expert review group that Dr Clark led prior to the establishment of the agency. There have been various other activities. Most notably, next year, 2020, in Sydney will be the largest space research conference globally, which we're hosting on behalf of the Academy of Science. There'll be approximately 3,000 delegates coming to Sydney for that. And we're working not just with the international space research community but also with the likes of Questacon and the Powerhouse Museum to embark on a STEM and education outreach, which will gather momentum towards National Science Week in 2020. That's when the conference will be held.

CHAIR: Thank you very much. Dr Grant?

Dr Grant: I'm here. I'm here on behalf of Myriota, which is a new space start-up. We provide secure, long-battery-life, affordable connectivity for sensors and devices for industrial applications that works anywhere on the planet. That is made possible through the commercial use of nanosatellites—so the same class of satellites that Professor Boyce just mentioned in the around about five-kilogram class of satellite. We operate a service here in Australia and globally right now with four satellites in orbit, collecting data for applications like agriculture, environmental science, logistics, asset tracking and monitoring, and defence, which are really made possible by a breakthrough in terms of the price and battery life that those devices can be offered at.

Myriota is an example of successful commercialisation of research out of a university. It span out of the University of South Australia in 2015 to commercialise an intellectual property portfolio that was built up as part of a research project that I led while a professor at the University of South Australia, which was funded by the Australian space research program to the tune of \$5 million. Since incorporation of the company, the company has raised private investment closing in on \$25 million and now employs closing in on 25 people and has four satellites in orbit and a successful product. So I think that's a really great story obviously for the company, but I would like to highlight that as a great story for Australia and how Australia is succeeding in the new space economy. Myriota is just one example of a company succeeding on the world stage. So we're about providing secure sovereign and affordable data connectivity globally. We're seeing the global spotlight turning on Australia: for example, a week or two ago, when Myriota was named on Forbes top 25 list of IoT—Internet of Things—companies to watch for 2019.

In terms of investment, I'd just like to mention again the global connections—our series A investment round, which last year was anchored out of Australia, out of Australian venture capital, and included participation from the CSIRO Innovation Fund Main Sequence Ventures, right click capital, but then also strong participation from Boeing HorizonX out of the United States and Singtel Innov8 out of the United States. So this is Australian technology developed in public research institutions making its way into the private sector, attracting significant private investment to offer a really important product in support of industries that we care about in Australia and that are also important globally.

CHAIR: Thank you very much. Mr Merino-Villeneuve, please go ahead.

Mr Merino-Villeneuve: I represent Airbus Defense and Space Australia. Airbus is a company more famous for its commercial aircraft, but it's definitively a world-leader in space. I have a three-minute speech to explain to you what we're doing.

Airbus is a major world contributor to space exploration and human space flight as well as a leading manufacturer of observation, navigation, science and telecommunication; a provider of launchers together with Ariane; and space systems, equipment and satellite imagery. Airbus is strongly committed to Australia, with over 1,500 staff today all over different places in Australia. Airbus Defense and Space has been enabling Australia's geospatial activities for more than 15 years and secure communication through our ground station based in South Australia.

We wish to make our experience available to Australia to continue promoting and growing the local space ecosystem. We have extensive experience in our companion nations in creating and growing their space capabilities. We're walking the talk in Australia as an active participant in the existing space footprint and we'll continue to sponsor and promote the growth of the activity to develop a strong competitive domestic sector that is able to participate effectively in the global market.

I think space activity is a natural fit for the Australian government's willingness to boost development of new technologies, a strong defence industry policy, an intricate investment plan and the creation of new growth drivers to deliver economic prosperity. Australia has long utilised the benefits of space, primarily through partnership

with NASA and the European Space Agency and its member countries. Australian world-class researchers and engineers are highly represented in spacefaring nations, and in particular in Europe and in our company; we've got quite a few members. Space activities stimulate the development of new technologies from an innovation and competitiveness standpoint and act as a catalyst for consolidation of related industrial capabilities. New space participants—Myriota is a clear example—are challenging traditional norms by relying on miniaturisation and new business models, which gives the opportunity to develop a space ecosystem at relatively low capital expenditure, technical and financial risk.

The new space paradigm, global digitalisation, Australia's strategic geographic position and its core capabilities offer Australia a decision point for a strategy to realise its potential as a leading country in space and space activities rather than being dependent on and supporting other countries' space capabilities. It requires a clear strategic vision for the nation's space capabilities and understanding of national space requirements, together with an assessment of the global trends and related business opportunities. The Space Agency has been established to coordinate all national space activities. We welcome that very much. In order to realise this space vision, Australia is benefiting from leveraging its existing strength and cooperative arrangements through a framework that targets specific capabilities of experienced industrial partners, like ourselves, to stimulate the local space ecosystem and assist in the commercialisation of its products, services and ideas. We are the first international partner to sign a strategic cooperation agreement with the Space Agency and we were starting to develop what it really means.

Australia is embarking on an amazing journey to space, and Airbus is showing willingness to be an active part of it. During the last two years, Airbus has strongly supported the burgeoning and talented space industry which has made Australia's space economy the fastest growing on the planet, with an increase of 35 to 85 start-ups in space. Airbus and the Australian Space Agency signed an agreement last year to explore collaboration opportunities on space discovery and technology development, and connectivity, science, technology, engineering and maths education in Australia. Airbus recently signed an MOU with the University of New South Wales Canberra Space, here represented by Russ, and Skykraft, which is a spin-off from the university—similar to what Myriota did with UniSA in the past—to undertake collaborative work to support the development of a small satellite mission.

We have invested as a tier 1 founding member in the proposed SmartSat Cooperative Research Centre, which was mentioned before. It's organised by UniSA and Nova Systems, and we do hope it's going to go and proceed this year. We've got a plan. We've got everything ready to develop technology that will help to sponsor overseas. We have just opened our high-altitude satellite flight test facility in Wyndham, Western Australia, to exploit the stratosphere—above the weather, at 65,000 feet—to enable Earth observation, communication and emergency management activities from Australia to Australia and other countries. This will enable the development of sensor technology and applications where traditional aircraft and satellites are either cost prohibitive or unable to provide persistent wide-area surveillance and communication. The creation of the space agency is welcomed by Airbus and will allow Australia to grow its industry and take advantage of current and upcoming disruptions to the space sector. Thank you.

CHAIR: Thank you.

Mr KHALIL: First of all, thank you very much for coming today. You are a wonderful cross-section, probably a great representation of the leadership in the space industry and space science across Australia. It's a very great privilege to have you all here today at this hearing, which I think is a critically important one. I congratulate the chair and the deputy chair for putting this topic on the table. It is a significant policy space for Australia. We're talking about a trillion dollar industry and—unless you know better than me—maybe even more than that going forward. It's also so important for our STEM professionals, our scientists and the country in so many sectors, as you've already described.

I just wanted to start with you, Dr Clarke. Congratulations on becoming the head. It's a very historic position—the first head of our first Australian space agency. It's a very exciting time for you and for the people coming on board to make this a great success. My first question is around your vision. We have so much expertise in this country already. In some sense, it tends to be a bit dispersed. There are a lot of things going on. Do you see part of your role as coordinating and consolidating some of that but also focusing on a couple of areas that we could really force multiply and get greater strides in? And what might they be, as far as your vision is for the next year or so? That is connected to my second question, which is around the plan for certain programs or projects that you might envisage over the next one to three years which we may start to get involved with in the context of where you think we should be focusing our efforts.

Dr Clark: Thank you for that. We would certainly like Australians to look up and see Australian ingenuity and creativity and be proud of what Australia is doing in space. I think it would be fair to say that, when we started back in the sixties, Australia was one of the few countries that was right there. We did not maintain that position, so we have a bit of catching up to do. Our vision is that we step up and take our role in this fast-growing industry, that we create some wonderful jobs around the country for people not just in the cities but also in regional areas—a wonderful place to connect with space—and that Australians can be very proud of how we enter this race, as I said.

In terms of the areas that we see as important, you're absolutely right: Australia can't do everything. We don't have the same investment that some of the other nations have, but we have an opportunity, as Valentin and Russ and Alex have outlined, in the new space era, where we can participate with some of the smaller satellites and some of the missions and joint missions. We've identified seven key areas that are very important to us and take advantage of our geographic position. We look into the solar system and we look into our galaxy, which is one of the reasons why we have the Deep Space Communications Complex in the European Space Agency communication centre in Tidbinbilla for NASA and New Norcia in Western Australia for the European Space Agency. Taking that wonderful advantage, there are a couple of priorities for us.

First, position, navigation and timing—that is, knowing where you are in Australia within our land and airspace and maritime jurisdiction. We are behind the world. We have five- to 10-metre accuracy. In the last budget, through Geoscience Australia, the government has invested to lift our accuracy around all of our jurisdictions to 10 centimetres and, going even further by setting up infrastructure with our mobile phone network, there's the potential for three-centimetre accuracy in our cities. So, this is an important priority and has effectively had significant funding from the government in the last budget. That will impact almost everything that happens in this country that relies on positioning: transport, maritime, agriculture—planting of the next row of wheat in between the rows of the previous year.

The second area for us is earth observation. We have never had our own satellite, so we got very good at using and integrating the data from other satellites for emergencies, for mining operations, for agriculture, and this is an area where we think Geoscience Australia has built a beautiful platform for integrating that data. We think we can export that. And that received additional funding. The other areas that we have prioritised are communication and ground stations. No other country would put a strategy of having ground stations, but it actually makes so much sense for Australia. As I said, we can connect to space very well. We've got a large area. We need to connect to communicate with across Australia. When you think about it, whilst 99 per cent of our population can make a mobile phone coverage, as you would be aware and as the chair would be aware, you can do that over only 30 per cent of our land mass. So, 70 per cent of the time you can't make a phone call. We think there are some really smart areas in Australia—the work that you've heard about already from Professor Boyce, for example. We're not world leading, but we have the potential in some of those areas to truly leapfrog to world-leading capability, and we would like to see that. So that's really our fourth area.

Space situational awareness: we are already a major known in tracking of debris through the US military and the US registry for that. We think there's capacity, as Lockheed Martin outlined, and Rod covered that we can look at both the military and the commercial area of that. Robotics: we lead the world in remote asset management. We manage operations in areas bigger than the United Kingdom, and we manage them from 1,000 kilometres away. We lead this in the world. We have the largest robots in the world, with the automated train in the Pilbara. We think that what we do in Australia can help what happens in space, and we can bring back some of the advances in automation to Australia. We also think access to space is going to be important for us.

This does actually come to getting into space as well—how we make sure that Australians can get their assets into space internationally and nationally. Those are some of the key areas. I think that probably covers your first question, and we will be working through our strategy through consultation and at the right time, and once we have worked through government process we will be publishing and intend to publish some of those strategic areas. Your second question went to the programs. Our first program, which was funded in the budget, is \$15 million for really kicking off seed funding for our international engagements. That's really the work we've started with the international agencies. The ultimate vision of that is that we will have joint missions with countries around the world and agencies around the world, and we are working through that.

Mr KHALIL: That's a very important point. I had the privilege of visiting NASA last year, and the director-general there basically made that exact point. He said, 'It's fantastic that you guys have a new space agency coming, and all the cultural exchange and all the educational stuff is great, but unless you do missions with us and other partners you're not going to attract the scientists, the STEM professionals and so on.' So, it's good to hear that the starting point is really to kick off that international engagement.

Dr Clark: It is, and that's really opening the door for our researchers and industry to participate and contribute their knowledge, their smarts and their equipment into these joint missions. The purpose of that is to open the door, but I think Australians are going to be really inspired by seeing our country participate in these missions.

Mr KHALIL: Thank you for that. The seven areas of priority are very clear, and I can see that it's been planned out really well. What is the time frame around the international engagement with the various other partner agencies around the world before you start really zooming in on a joint mission or a couple of missions that may apply to one of these seven areas? Are you looking at a three-year cycle? Five years? What's the planning?

Dr Clark: It's a great question. We've kicked off that engagement already. We started in July. We signed our first agreement with CNES, the French space agency, in September, and most recently we've signed with the United Arab Emirates in February this year, just this month. Our funding for those engagements, our first \$15 million, kicks off in the next financial year, so that will be the start of where we will work. What we have already done in those MOUs with the agencies is outline the areas where we want to work. With Canada, for example, we're working on Earth observation and robotics. With the French space agency, one of the areas we've highlighted is next-generation smarts inside satellites, and the work that Professor Boyce has been doing is an example of that. In each of those areas, we've highlighted areas that we want to work on, and now we will work towards having that program policy set up, and then we will be able to move into those agreements.

Mr KHALIL: I know you outlined the MOUs at the start. It was Canada, the UAE, the UK and the French space agency?

Dr Clark: Yes.

Mr KHALIL: And NASA as well?

Dr Clark: No, we have yet to finalise our agreement. NASA's a very big beast with a budget of \$20 billion a year. We have had a very longstanding relationship with NASA going right back to the landing on the moon. As all Australians would be aware, Australia had a critical role not in stepping on the moon but in the world seeing that and watching it on television, which was really extraordinary. So we have a long history with NASA, and we're certainly already commencing discussions. I've met with the administrator from NASA several times, and we will be working on extending our partnership with NASA as a priority.

Mr KHALIL: We all know the challenges STEM professionals have in Australia and the struggle that mid-career scientists have to write grants and get a steady professional salary and a stable career pathway. There are a lot of challenges there for mid-career scientists. Obviously, a lot of our STEM people have gone off to Silicon Valley. I was there visiting a number of the companies that do microsatellites, and half the people there were Aussies. It was remarkable. Is there a plan, with all of this work, on bringing back some of our brainpower, as it were, to work on all of this? Is part of your thinking to bring the STEM children home, as it were?

Dr Clark: We would love to create some opportunities.

Mr KHALIL: We just need Moses and they're out of there! Megan might be able to part the seas!

Dr Clark: I think that if we achieve our objectives of growing the industry, if you see what Alex is doing with his company, we can grow those jobs as new roles. Alex, I can't remember how many people you started with, but it was probably only one or two.

Dr Grant: It was one.

Dr Clark: Yes. So already you're starting to see this creation of jobs. We know that creating the jobs is not necessarily going to be in the agency. Our job is to create those roles in the industry. In the activities that are happening in our universities, our research agencies and an industry, we're already seeing the seeds of that. We are already seeing a pipeline of just under \$1 billion of capital investment in the next three years, and just under half of that is inbound capital. These are the sorts of things that start to build those jobs—and even, as Valentin has outlined, having Australia's first launch and retrieval site for a high-altitude pseudosatellite or stratospheric drone in a place like Wyndham, where my understanding is that the population is not much more than 400. It was wonderful to see some 40 specialists from Airbus and locals now working in Wyndham in very extraordinary jobs. That was literally a 10 per cent increase in the community. These are the sorts of jobs that we would love to grow in Australia.

Mr KHALIL: This is my last question. I have other questions for the other members, but I'll let others go before me. Thank you, Dr Clark, for your full answers. I know the government has funded the Space Agency with, I think, \$41 million, and we've also committed our funding in opposition. If we were to win the next election, I think it would be a little bit more. Sorry, Chair; I just remind everyone of that. But it's about the same.

My question, really, is into the future. Are we talking about much bigger funding envelopes, particularly when joint missions start, when bigger projects are on the runway, as it were? Is there an estimate around this? Are you dependent upon whatever the government's willing to commit or is there a sense of knowing how much you need from the government, and to attract private investment and capital for some of these projects?

Dr Clark: Certainly, at the moment, our priority is working through a strategy with government. We're working through a 10-year strategy and our strategic priorities. Once that work has been completed, the next stage is to work on our investment plan over that 10 years, to at least put a framework around that. As you would not be surprised, working through and making sure we have approval for that is a complex activity of government. I think, philosophically, our approach has always been that the pressure should be on the agency to demonstrate its capacity to improve the lives of Australians and to genuinely diversify and lift our economy. We're also very cognisant that we must deliver before we can go back and ask for further funding.

I think the resounding funding in 2018 was some \$300 million. There was \$41 million to the agency, including the \$15 million to kick off our international, but another \$160.9 million to Geoscience Australia for the positioning work increasing our location accuracy to 10 centimetres. Another \$64 million went to Geoscience Australia to set up the infrastructure for this precise positioning. And there was some \$36.9 million for the Digital Earth program, in our platform for earth observation, which many countries show an interest in adopting. I think that's a resounding start. And it has not been lost on the international community that Australia has made a very strong start.

We also must remember that underpinning that is a strong ballast from defence investment in the space sector. Some \$10 billion over the next 20 years has been highlighted. So you combine this investment and we're starting to see what I would characterise as a significant momentum in the country.

Mr KHALIL: If a future federal government noted the good work that you've done in the planning stages and the strategic plan, and a joint mission started to crystallise, is it the case that a big funding boost by federal government to help that nation-building mission attract attention—you talked about inspiring young people. This is the type of thing young kids love. That's why they get into science. Strathmore Secondary College is a great example. They've got a set-up there of mission control and they've got simulation and all that. This is why kids get into science. It's also why people stay in STEM and come back and work.

The big thing I learnt on my trip there was that NASA didn't have to compete with all the money Silicon Valley was throwing at these kids. I asked them how they'd compete with the bar on every corner of every workstation and the free food and drinks and a place where pets can play at these transport companies, like Lyft, and all that. They said, 'We don't have to worry about that. People come here because this is about a sense of purpose. They're involved in history. They're involved in something bigger than themselves, so money's not the motivation.'

So is it the case that a big funding boost, to get that nation-building project up, would be something you would support? That's probably a leading question.

Dr Clark: That's a matter for government.

Mr KHALIL: That's a good diplomatic answer!

Dr GILLESPIE: I have a couple of questions. Thanks, very much, Dr Clark, and everyone else who's given presentations. I was interested in your comment about ground stations with satellites—ground stations to connect broader parts of terrestrial Australia, rather than stratospheric Australia, with satellite communications. I'm just seeking clarification.

Dr Clark: Let me, just briefly, cover that. There are different types of ground stations. There is telemetry and control of ground stations that can receive but they also control the communications satellites, and we have those high-end satellites. For example, the NBN has 10 TTNC control stations around the nation. There are also ground stations which simply receive the information—data et cetera. So there are different levels of ground stations. Certainly, we can provide public information on the map of where we have ground stations in Australia.

Dr GILLESPIE: Mr Merino-Villeneuve and Dr Grant, you were talking about the microsatellite space. It seems like that is the logical thing: all the energy to get a massive satellite up into space shrinks exponentially; instead of a Saturn 5, you could have a small rocket. Is that a realistic project that we as a nation should get deeper into?

Dr Grant: Myriota had such a satellite on a Falcon 9 launch as part of the SmallSat Express mission, as did MSW and some other Australian companies and research organisations. So that is already happening using that class of large rockets in rideshare scenarios. Myriota has recently announced a partnership with US based nanosatellite vendor Tyvak for our next three nanosatellites, and we are looking at the current availability of launch options for those satellites.

The really interesting thing for commercial space is that that bar of entry to space is decreasing, the cost is decreasing, and the types of launch vehicles that are available and opportunities and cadence—how often you have access to a launch—are increasing incredibly at the moment. There are more and more players. For example, Rocket Lab is launching out of New Zealand, Virgin Galactic is launching from aircraft and there aren't many options coming to market at both the big end of town and in new space start-ups.

Is there a role for Australia there? I've lost count of how many Australian start-up companies there are that are doing things with either propulsion, rocket engines, vehicles or concepts around launch. That is something that has really been happening over the last five years.

Dr GILLESPIE: But is there potential for us, because of our geography and space, to get into the launch part of a system rather than just the—

Dr Grant: From a geographical perspective, yes, absolutely. That's why Rocket Lab launch from New Zealand. Those latitudes are amenable to some very commercially important orbits, which companies such as Myriota build our business on.

Dr GILLESPIE: You mentioned that there was \$10 billion in our Defence budget over the forward estimates. In what direction is that Defence money going—joint programs or just capability so we can see from space what's happening over our nation?

Ms Higgins: It was announced initially, through the 2016 Integrated Investment Program, that over the next two decades Defence will be spending about \$10 billion on space projects. That includes satellite imagery capability. These figures are forecast out to 2023, 2029, 2033 and 2039. From 2017 we have started spending some of this money. But it does go out several decades. It is looking at space situational awareness systems and radars, at position navigation and timing capability. There is up to \$3 billion to spend on Australian defence satellite communications in the Integrated Investment Program. There is the Collins class satellite communications and maritime communications modernisation.

Mr GOSLING: A lot of people don't realise that in Arnhem Land there used to be an ELDO facility that used to track whatever when it was leaving Australian airspace, and there's a company called Equatorial Launch Australia that is interested in doing something again in Arnhem Land. Is it true—this is a bit of a leading question, I suppose—that being close to the equator is advantageous for launches? That's an open question to anyone. If that's an advantage, that's good.

Prof. Boyce: If you want to go into a low-inclination orbit—that is, roughly tracking above the equator, plus or minus—then you must launch from that area, from near the equator. There are many orbits, however, which are very advantageous for earth observation, and they are almost polar orbits, so they're going north-south. You don't need to launch from Arnhem Land, for example, for that.

Mr GOSLING: What about geosynchronous?

Prof. Boyce: If you're going to geo, you need a lot of energy to get there, and launching close to the equator assists in that regard. You get the spin of the earth helping a little bit.

Mr GOSLING: Are there any observations from anyone here on a great opportunity that the government's not currently looking at and should be, from an industry perspective or—

Mr Murfett: I could cover a little bit on the launch. We're aware of a range of companies that are looking at launching in a commercial sense. Rocket Lab is a good example where they launch up to 150 kilos, and that's in the nano-launch capability. What we've seen with the establishment of the Australian Space Agency is an enthusiasm in the commercial market, and companies such as Equatorial Launch Australia is one of those. Importantly, one of the things we talk about within the agency is that we're also a regulator. So, with the commercial activities that are underway, it's a commercial proposition to undertake that and they need to determine if it can be a commercial market for Australia. It's been outlined where those opportunities exist. One of the things that's very important with launch activities is that they work with us, as ELA is, to make sure they understand their regulatory obligations and the international treaties that we need to abide by. With the interests of those companies, they're working pretty closely with us. As we explore commercial launch, I think the important thing that the agency will do in that sort of context is make sure that we set the right regulatory environment so we both balance entrepreneurship and, importantly, meet our international obligations and ensure public safety as we undertake those activities.

Mr GOSLING: Who manages globally the international regulations? Are they done through the UN or something?

Mr Murfett: The international framework sits under the UN, under a group called COPUOS, which is the Committee on the Peaceful Uses of Outer Space. There are five overarching treaties which were signed in and around the 1960s. The most important one is known generally as the Outer Space Treaty, and that sets the requirements for how countries cooperate in space to ensure it's open and safe for all. We have enabling legislation in the Space Activities Act 1998 that actually recognised some of those requirements that are on a country should it wish to launch. When we talk about a country wishing to launch, that includes companies within that country that wish to launch. As the administrator with our minister, who's the responsible minister for those matters, we provide advice on licensing and other requirements.

CHAIR: I just want to go through things. I obviously respect the deep knowledge that Peter has. I think it's important that he leads a lot of these discussions. I want to go through a couple of these things. I read some time ago, at the start of the so-called space race, that Australia was the third country out of the blocks: the United States, Russia and then Australia. Apparently, for some unknown reason, we just disappeared off the block, and now we're trying to catch back up to so many other countries that are more prominent. What is the top of our role in that new much more crowded market? Where is our greatest proficiency going to be? Anybody?

Mr Murfett: Chair, I might start, and then people around the table might contribute. If we're looking at space, we go from the 1960s, Saturn 5 and when countries were involved with the US and Russia, which was known as the space race, to now. We fast forward 50 or 60 years into this new space agenda, as it's being termed, and that's being created because technology has got smaller—do have a look at Alex Grant's device; he usually has it in his pocket. Smaller technology is enabling launches to get cheaper and the innovation cycle—the amount of time it takes to get new technology out to the market—to really reduce, which means that the role of government has gone from that big investment that you would have seen in the sixties to government moving in to partner and facilitate—for example, connecting with international counterparts. It's the companies, small, medium and large—and we've got many representatives of those types of companies—that can build the products themselves. So we can have companies that build CubeSats, that can put new cameras on or build new communication devices that can go into space. Our role, then, in the Australian context, is one where we've got a really strong R&D base. A statistic that is often used is that for around 0.3 per cent of the world's population we generate around four per cent of new knowledge, and that's through publications. That means our R&D capacity, which exploits and goes into new technologies, is quite profound, and we're world-renowned around that. And that's not different to what we're seeing in the space sector.

As we look at our opportunities, Dr Clark has outlined the six or seven areas where we're looking at those opportunities. What can we do around communications? How can we improve communication technologies? How can we build new, nimble satellites? How can we monitor things in Earth? The thing that Australia can do—and this is some of the work that we're thinking about—is look at those international missions that are happening. If we use NASA, for example, they're going to develop something called the lunar gateway. That's a spacecraft that orbits around the moon. They've got a lot of capability, but they've got gaps in the capability that they can provide. I use the hypothetical example that we have the mining industry, so when they're orbiting around the moon they need low light sensors, they need robotics and they need AI. What we're doing is looking at those gaps in the markets in these really future missions, and then matching it to the capability that resides in Australia.

CHAIR: To continue on with that, Australia has an incredible capacity to develop ideas—whether it's a computer, whether it's wi-fi—but then the equipment is forgotten about as other people copy them and steal them. If we have new investment into the industry, as we do, who owns the IP? How do we protect any of that? How do we explain to the Australian people if we are incorporating some of our design facilitation—being basically small parts—how do we protect the intellectual property of that and show the Australian people that for this \$10 billion investment we retain the patent rights on all these things and there's a return coming back to the Australian people.

Dr Grant: Perhaps I can comment on my experience. The development of world-leading intellectual property that stands up as best in the world in whatever it does is something that Australian R&D delivers again and again. Doing that R&D is one thing. Protecting that in a strategic way and then delivering that to market is another question, and that step is difficult to do. You can mess it up by getting your strategy wrong. You can get the commercial part of it wrong. You can get the marketing wrong. But having a strategic focus on the development of protectable IP right from the start of any program, whether it's an R&D program like what we did or some broader mission, that's the key thing, and that's something I like to refer to as premeditated commercialisation. It's having the commercial goal in mind at the start, rather than doing the research project or the mission and then, at the end of that, saying: What IP is there? What do we do with it?

So having a strategy in place is important and, in my view, getting IP into the hands of people who can attract investment, to then take it to market in whatever way makes sense, is important. Typically that means the private sector, sometimes in partnership with the public sector, but always it's making sure it does actually reach market.

CHAIR: I think Dr Gillespie has an addendum to my question.

Dr GILLESPIE: Dr Grant, I take on board your comments. Is there any awareness of what other countries are doing? I'd like to bring to your attention that other nations, like the UK, have patent box tax treatment of UK-generated IP. If you look at IP as the tip of the iceberg, the long-term growth of the economy, employment and the wealth of the nation are the commercialisation, but we have a shallow habit in Australia of taking a one-off sugar hit, selling the IP and letting somebody else do all the commercialisation. In the UK you notice the same thing. You get a discount for the company's work if they're commercialising UK IP. Some of us in this House promoted that in 2014-15 but it seemed to fizzle out. Would that be a benefit? This is something the government could do not just for the space industry but for all Australian IP.

Dr Grant: Anything that the nation can do to promote the indigenous development of its own IP and to take that to market as a nation is really important. There's a big difference between that and—let's take my case—coming out of a university technology transfer office, casting an eye around, saying, 'Oh, here's something,' and licensing it to a US company, a UK company or somewhere. That's fine; you'll make something come that way. I've actually done the numbers on that, and universities make less money on stuff like that than they spend on photocopying. It's not a scalable, economy-building thing to do. You get the one-hit wonders, where it blows the roof off and it's amazing, but what is much more important—and this is something that I've tried to do in my own career—is to take the people along with you.

Taking my own company, Myriota, as an example, it's bringing smart people out of research institutions, because they're the people who generated the IP and who will continue to innovate. It's telling that we took a portfolio of 10 patents out of the University of South Australia in 2015 and, since then, we've doubled the size of that IP portfolio as a commercial entity to continue to innovate—and then more staff and more products to continue. That is something that attracts investment, which then creates new jobs and grows an industry, which—pardon me—just flogging off IP isn't going to do.

Dr GILLESPIE: But would a tax discount on that sort of IP development be attractive to any company, not just your company?

Dr Grant: I think the nation has things in place—like the R&D tax scheme, which is very broad. Something like what you're suggesting sounds really interesting. In my view, any commercial development of IP has to stand on its own and be internationally competitive. However, I think that as a nation we do need to recognise that other nations are boosting their versions of that with schemes like this, and that's what we're competing against in Australia.

CHAIR: I might just finish off my line of questioning. Some time back in the agricultural sector we had Beeline, which incorporated GPS. One of my clients was taking it the next steps with Glonass so we'd get greater interrogation of, basically, two provided databases to get a more precise delivery. I thought that had already reached, some years ago, one- or two-centimetre precision on agricultural equipment, so when you mentioned getting the precision below three centimetres I couldn't quite work that one out.

Dr Clark: It's a good question. Many farms invest in actually having a correction tower, if you like, on their farm, so it's an investment made to be able to give the precision to the harvester or the equipment, and then they're using John Deere's kind of network around the world. But that's an investment that's made to get that level of accuracy. What we're talking about here with the platforms that Geoscience Australia will have responsibility for is that that sort of accuracy will be available to people who have the application. It's shifting from having to make an investment that is quite localised and getting that accuracy perhaps on an individual farm to being able to offer that around the country, which then you could use for transport in the cities and you could start to use for applications et cetera.

CHAIR: Driverless cars.

Dr Clark: Exactly. Also, during the preparation for the investment in this, Geoscience Australia supported, I think, some 27 partnerships and trials and projects around the nation, to start doing testbed facilities and testbed projects that were led with Geoscience plus one of the CRCs. So there were also a number of trials that were on the ground. I'm not familiar with the one you particularly outlined, but it could have been either that direct investment or part of a trial.

CHAIR: There was investment. They had to have their own structural tower on the place where they were doing it. Then they could be more specific. They could show us and say, 'We'll just use GPS, unless we get

GLONASS on, and then we'll have multiple points of trigonometric measuring that give us a vastly more precise outcome of exactly where we're going.' Even at the time, I thought it was incredible how precise it could be.

Dr Clark: Taking that model, then what you can do with the precise positioning project that's being funded is you can start to use the towers of the existing mobile phone network. That's why the precise positioning of, perhaps, three centimetres is really in the cities at the moment, because you need that tower infrastructure. But that would be a big boost for us. As you said, you can see the potential.

CHAIR: Precisely. That's what the farmers will do. A lot of them, especially the big farms—the big cotton farms, the big horticultural farms—actually use it. It has an absolute commercial return to them to be precise. They were considering it basically for tractors and stuff. The only thing the person in it has to do is turn it around. Even that can be done. He just sits there as a precaution, not really for a purpose. But they needed mobile phone towers. They said, 'If you don't have mobile phone towers, we cannot do this form of farming with the precision we want.'

You were talking about orbit. We're getting more and more cluttered up there. If people don't participate in a formal process of registering their route, then ultimately—even though it's highly unlikely—something is going to bump into something else, or space junk from one is going to bump into something else and cause massive problems. How are we going in the licensing and certification of orbits of satellites in light of where China's propensity to obey the rules is?

Mr Drury: The short story is that we haven't made a lot of progress. There's been a lot of discussion. Let's go back to the basics. In the geosynchronous orbit, which is where the larger satellites are, they are effectively in an allocated orbital slot, which is actually purchased. It's effectively a land lease, if you like. The satellite sits approximately at 36,000 kilometres from the earth and will conduct what's called a station-keeping manoeuvre, which is normally a little series of figure eights. It will effectively stay within a particular—let's call it a locational box. The geosynchronous orbit is well maintained. As I said, the positions are available. With the advantages you have out of modern technology, you are able to layer satellites in those locations. Ten or 15 years ago when you put a satellite into your parking slot, it was only one. But a lot of companies these days are actually stacking satellites, and we designed our satellites, like the other major providers do, so that they can operate in a stacked environment. But there is a limit to that.

The real issue is your ability, if you want to take a large satellite to do synchronous, to do what they call geosynchronous transfer orbits or for any of the other orbits that are lower than that. So when you're talking about a low Earth orbit, a medium Earth orbit or other variants of those orbits, it's basically what we used to call in the flying days 'see and be hit' or 'see and avoid'. You've got to rely on a lot of data from a number of different specialist providers around the world. What you do is you plot your mission, you launch accordingly and then you hope that, through all the analysis and work that you've done, the path to where you're trying to get to is clear.

CHAIR: If I buy a lease or pay my licence for an orbit, where does that money go?

Mr Drury: That goes to the organisation that operates it on behalf of the corpus.

Mr GOSLING: To you?

Mr Drury: No, to the international organisation that manages all that. Let me explain it this way. It's a bit like having a land lease where you don't have a driveway access. You've got a plot of land that you own and that you need to get to, but you've got to negotiate through a whole bunch of other properties to get there. In a land sense the property owners would know what's out there: 'Could you shut the gate, make sure you don't do this, make sure you do that,' but when you go into space you don't know, unless you've got access to very detailed information that's provided by companies contributing to space situational awareness. Then there's a challenge. The positive for you is that this topic has actually been raised at a number of international workshops, some of which we are running at the moment yearly, believe it or not, out of Scotland. The community is getting together and looking for what I would effectively call a set of space rules similar to what we have in air traffic management, so that people basically have to flight-plan and that people know that in certain orbits they have to give away to other orbits. Let me assure you that this is a very contentious discussion. As was alluded to a little earlier, the problem you have with most satellites—not all satellites but most—particularly traditional satellites, which are chemically powered, every time you fire to change your location you're effectively diminishing the life of that satellite and therefore the potential return of that satellite. The problem you have is that most satellite operators generally don't want to manoeuvre unless they absolutely have to, because they are limiting the potential revenue return on their vehicle. This is a major issue that we're trying to wrestle with.

CHAIR: Unless everybody who has the capacity to put up a satellite complies with an agreed set of international laws you definitely will get one pounding into the other, and that in itself entails an increase in costs,

because you'd have to say, 'I'm going to take up a contingency in the event of this occurring,' and that would have to be covered in the cost of my matching your assessment of the value of this hardware and its capacity to last for 15 to 20 years rather than just being up there with sort of a bit of a game of dice.

My final question is pretty broad, but it's something that I know high school students and everybody else want to see: will we get to a point where we can actually go to a launching pad and see an Australian rocket delivering an Australian made satellite into space? I know you, Professor, have been instrumental in the higher ranking, or world-leading, development, especially in scramjets. Is that a prospect? To be quite frank, to enthuse the public they want to see something tactile. They want to see something take off. They want feel a sense of pride that this is an attachment to an investment by the Commonwealth. It's tactile, and therefore their interest is more involved than saying, 'Do you want to get involved in the regulation of space?', to which they'd say, 'Not particularly as much.' That would certainly enthuse my reasons for it. Is anybody likely to do that?

Prof. Boyce: Perhaps if I have a go at answering that: I personally don't believe that scramjets, for example, are going to put satellites into orbit—Australian or any other scramjet. There is the possibility that an Australian developed rocket could put that into orbit.

CHAIR: Is anybody developing one?

Prof. Boyce: Gilmour is an example of a company in Australia, in Queensland, that is developing home-grown rocket technology that could well see fruit. My personal belief though is that the more important thing is not the rocket, because there's the possibility that global commercial pressures will conspire against the success of local companies. That's a high pressure. What's more important for Australia and, I think, what many young Australians would value is the things that you do with technology in orbit to meet needs on the ground, needs that young people care about, that opportunity is not just a high probability; it will happen. We'd have to make sure that the public is educated and brought along on that journey.

CHAIR: He's dead now but my former brother-in-law, his father was a rocket scientist at Beijing University so the story was always conveyed back to me that when someone says 'it's not rocket science', he said, 'I don't know what that means but rocket science isn't really that complicated.'

Mr Murfett: I might just add, with the establishment of the agency, we've seen a huge interest with a range of companies looking at launch. We've talked about Equatorial Launch Australia, and Professor Boyce has spoken about the Gilmour Space Technologies, which is the capability they're building. We're seeing that appetite building. What we're turning our mind to is to make sure the environment is right because, I think, in a couple of years' time, the reality will be that there will be active interest in launch around those areas and putting Australian technology out there now. This is at the nano. This is in the small scale; we're not talking about the big Saturn Vs. But we are thinking if we look at the context of rocket labs and then launching and that inspired their nation and then that inspired a lot of commercial interest as well because that will have implications for lowering cost in the market. But as we look forward, that's something we're actively considering because we think it's a reality. So that means that our role is to make sure the right regulatory environment is there so it's safe and balanced in the entrepreneurship as we go forward.

Mr GOSLING: Thanks everyone for your time and feel free to contact me later if there's anything you missed out on saying today. The Northern Territory government has got a one pager. I've left copies at the bottom of the table there with contact details of the Northern Territory government and the people who are looking after their space strategy. If you want to connect with them and discuss anything, please feel free. If I can help in any way to facilitate, let me know.

Mr KHALIL: It's been a really great conversation. I should add, just for the record, we are going to start up a parliamentary friends of space. I'm going to be one of the co-convenors and your colleague from the Nats Kevin Hogan is the other coalition-convenor so, hopefully, we'll have a really good opening event. I don't know when that's going to be because we've got three days I think for the budget and then we might be going to an election pretty much.

CHAIR: You have to be careful the terminology; otherwise you will have heaps of people turning up.

Mr KHALIL: We could call it 'friends of space science' or 'friends of space industry' but we'll refine that. And obviously there is an open invitation to all of you to attend the first event. We might have something special on the first event. We'll try and get a lot more people across the aisles and MPs and senators to come to this for the understanding of how important this industry is and how important space science is to Australia's future.

Just to finish off on the launch side of things, I think it is important we do make that distinction of launch capability in Australia. There are a lot of companies that you've alluded to up in Queensland and other parts of the country that are interested in getting a launch capability restarted here, which is different to actually making the

rockets. But I visited SpaceX and saw their operations there, which are remarkable—that reusable rocket technology. Obviously Musk is hitting a wall a bit because the missile laws in the US mean that he can't open up launch facilities outside the United States borders, which means there might be an opportunity for us here to compete at some level. I think Kazakhstan's the other place where there's a lot of launch going on and some other places around the world. So from what you said, I think, this is happening or there is a real commercial drive for this to go into effect, and we might have some launch capability happening in this country. That's one question. I'll be interested in views on anything the government can do to help facilitate that.

The other question I had—and I'll just give you all the questions now so we can have a discussion about them—was really around competition and collaboration. I think you summed it up pretty well when you said that, in the past, in the sixties, when governments were controlling a lot of the investment in space exploration and space science, counterintuitively you could almost control the competition of other states because it was very contained. You knew that the Soviets and the Americans might coordinate on one thing, or the Europeans, and you could really control it. We're in a different world now, so collaboration and competition tend to become very blurred—and I think David touched on that with the IP stuff—and this becomes a much more complex set of challenges. I'm interested in your views, all of you, particularly the private sector, about that, and if there are any regulatory frameworks that can address those challenges. We know the Chinese have already put, I think, a robot or a rover on the far side of the moon, just a month or a couple of months ago—a significant mission there. So, in collaborations with all these other agencies, how do we protect our R&D, our IP and all of that, and, also, how do we make sure that there is not going to be direct competition, particularly for our defence and security elements? I'm interested in your thoughts on that.

On the lunar gateway, we had a wonderful briefing at UNSW—I was there—last year, with your head of space engineering, the professors, and some of the PhD students who have been working on modelling around our contribution to that, whether it's AI, automation or even processing water off the moon, which is really quite an interesting thing. But fuel is needed for the lunar gateway and for the space station and all the rest of it. So I'm interested in your views on that, Professor Boyce.

Lastly, Dr Clark, of the seven priorities that you set out, the fourth was really very open; it was kind of like where we could become world leaders. So I'm interested to hear where you think that might be, because some of the other seven are areas we could be; we've already got a leading edge on situational awareness and space junk and monitoring it. Would that fit into priority 4 as well, where we can really ramp up that leadership?

I think those are all my questions. Thank you in advance.

Mr GOSLING: Sorry, Chair, I've got to go. Obviously, there are a lot of peaceful applications, but there are also some offensive operations. I get the feeling that there's stuff going on in space that's offensive in nature, and defensive, and this is not the place for a brief on that, but I'd be interested down the track in finding out how we're faring there. Thanks, Chair.

CHAIR: You're welcome. Any questions, Dr Gillespie?

Dr GILLESPIE: Yes. Thanks for coming along. I'll certainly be joining the parliamentary friends of space. I'll be a space cadet!

Mr KHALIL: You can be my No. 1!

Dr GILLESPIE: Mr Merino-Villeneuve, in your information, you gave a briefing that you're involved in the project up at Wyndham and you said you're the second-biggest space business in the world. Is that because you've joined up all the various European space agencies under the Airbus umbrella, or has Airbus just gone from zero to hero in a very short space of time?

Mr Merino-Villeneuve: No, Airbus rebranded the space company we used to have, which was called Astrium. It used to be called Astrium, and Astrium was a European consortium, as Airbus is for commercial aircraft. Between Astrium, Airbus and other defence companies, we just rebranded ourselves as Airbus. So it's not something new. That's been for the last 40 or 50 years, and it's part of the collaboration of Europe into how different countries can work together. So it's France, it's Germany, it's the UK and it's Spain working together under one brand—several different countries specialising in different capabilities, but in the end we are one.

Dr GILLESPIE: Have you got other interests in the country, besides the thing up at Wyndham?

Mr Merino-Villeneuve: Yes, absolutely. We've got an anchor station in South Australia to tap into the UK MoD Skynet 5 constellation. That's where we've decided to install our anchor station to provide services to all of this region, not only Australia. And we are actually looking at opportunities to anchor older types of ground stations, more in the optical segment—so, how to communicate via laser—because we are installing laser communication between satellites as we speak. So, from GEO you can communicate to LEO while images are

being captured. Instead of waiting for those images to be dumped into the ground station, they can go directly to GEO. You'll have a geostationary satellite just in this latitude. So we are thinking that Australia is a location where, hopefully, we can install that type of capability.

Dr GILLESPIE: I was going to ask you and the broader community what's happening in the laser space. Everyone knows about death stars and zapping things and *Star Wars*. Again, a lot of it's probably secret squirrel stuff, but is there an appetite for that technology to be developed here as well?

Dr Clark: I am able to answer that. Being a country that developed wi-fi, we're looking at the next generation of communication in space that will need and require that additional bandwidth. As Valentin outlined, with laser communication already being used in space for much higher bandwidth than we currently have, the next stage is: how do we bring that to earth? The Germans have already done tests from lab to mountain top at 13 terabytes a second. That's about 500 times the 5G that we're all looking forward to. It's another step of 500 times that. So that's the advantage of laser. We're already seeing commercial activity in terms of uplink and downlink. One of the disadvantages of laser is that anything that gets in the way is not good, so you need to have redundancy. That's where it's very different from the current radio signals that we use. If you had to choose a country, you would probably choose the Altiplano in Chile—right up there, it never rains et cetera. But if you had to choose a second-best country, Australia is pretty high up on that list. We have some geographic advantages for downlink of laser and multiple downlink of laser. It's very important and this is one of our priorities in the communication area that Australia is not left behind in what is this really next generation of communication. As I said, it's driven by a relentless requirement for bandwidth. It's a very important area, so we're very happy to provide updates on how we're progressing with it.

CHAIR: There are three organisations now that are having connections with 13 terabytes, and that is the NBN—No. 1—and then it's Optus and then it's Telstra. If they can do that speed using wireless then we've just planted in the ground billions of dollars worth of technology, which could very much be envisaged as being worthless very quickly.

Dr Clark: Just to sort of calibrate that, one of the first trials of laser downlink kept having intermittent signals that were random, and they couldn't quite work it out. Eventually, somebody actually went to the receiver and realised that there was a large spider moving backwards and forwards. So just to calibrate that, the difficulty, as I said, of laser is interrupting signal. Whilst there are advantages, certainly for our foreseeable future the use of the radio spectrum will be critical.

CHAIR: You could have one of those little blue wires that go round and if they touch it—

Dr Clark: I knew you would pick it. Some of the huntsmen in Australia we'll need to be controlled.

Mr KHALIL: I have three questions. Is that okay, chair?

CHAIR: Sure. But we just want to make sure everybody has got something booked in.

Mr KHALIL: This can be very quick. The three questions are around your views on competition collaboration—that conundrum; the launch and whether the government needs to be involved in that or whether it's purely commercial; the lunar gateway; and, of course, Dr Clark, where you think we could actually be leaders.

Dr Clark: Let me just answer where we think we can be leaders, and then I'll hand to the deputy head of the agency for the others. There are many areas in the leapfrog where we think Australia can play, certainly in the use of quantum technologies in security and cyber as well as the securing of information are very important areas in communication. Novel propulsion systems: companies like Neumann Space are developing propulsion systems using plasmas—so little bursts of very, very high energy ions. Propelling satellites when they're on orbit does not need a lot of propulsion, but we have some really nice technology in that area. We also have some interesting areas in rocket design and hybrid rockets as well. So there are many areas for us that I think herald some wonderful opportunities.

Other areas which might not immediately come to mind include space medicine. We've advised NASA for over 40 years with our work in Antarctica, and yet we've never had one of our doctors as the lead medical officer on a joint mission. We think there are opportunities as well in space tourism. There are many areas; that's really just to touch on a few. There is a role for government to stimulate some of those areas and then allow them to take a position globally in a globally leading area, if we can give them a bit of a kickstart as government and then let them take their place in a competitive role. Let me hand those other questions to Mr Murfett.

Mr Murfett: I will just cover the launch question. I won't speculate on the future and the role of government—that would be inappropriate—but I'll talk about what we're doing as an agency. We very much see that it's a commercial opportunity and companies are looking at it through a commercial lens. We're looking at it from the point of view that that's the opportunity and those companies need to determine if there's a market, and

we've had some of those examples about whether that will come forward. What we need to do is plan for that, and that's what we're doing because we're seeing the interest. What we've got to manage is not only the entrepreneurship side—and there's the growth of the companies and their interests—but also the international obligations and making sure that, if they're undertaking launch sites et cetera, there's public safety and also coordination across government with other agencies such as CASA and local authorities around environmental controls. There's actually a lot of work that needs to go into launch itself. So our role at the moment is in advising companies that are interested in launch that there are a range of requirements that they need to undertake, and then we're working on the regulatory requirements to make sure all the right frameworks are in place should a company come forward looking to put forward either a launch site or otherwise. That may take up to a couple of years, but we know the companies are interested and we're planning for that as they undertake those activities.

Prof. Boyce: Yes, the lunar thing. There's very much a place for Australia to be enabling the participation by Australians and Australian organisations in international planetary exploration and deep-space missions, because that can inspire and can also generate very interesting spin-off technologies which can be very useful on the ground. Should Australia be investing large amounts of money in playing a leadership role in such a mission? In my opinion, we might well do that one day, but there are more important things to be spending large amounts of money on first closer to home. There are some significant opportunities for Australia to invest in developing world-leading space technology that kick some serious goals on the ground. I mentioned earlier the combination of space technology and artificial intelligence aimed at real-time delivery of decision-making quality information direct to users—whether they be in defence, national security, farming or the resources sector, it doesn't matter. Those are more important from a pragmatic perspective for Australia short term. But participation in those deep-space science inspiration activities is a good thing.

I would add one thing: we need to be asking not only the question, 'Can we do it technically or financially?' but also the question, 'Should we do it from an ethics point of view?' Some of the international treaty wording is around what it means to be a good citizen of space and of the global commons. It turns out that Australia is becoming a world focal point, possibly the world focal point, for the development of space ethics considerations. That discussion and that line of thinking should accompany any investment.

ACTING CHAIR: We're signatories to the Moon treaty and the Outer Space Treaty—I'm aware of all of that. This fascinates me. If there was engagement in the lunar gateway, or whatever it might be, would it all be funnelled through the Australian Space Agency? Would you be working together, or is there a potential here for private companies to do this on their own without coordinating with you?

Dr Clark: Our job is not to—they didn't want the agency to have everything involved in the agency. What the nation was really clear about and what the message to us was: fill in the gaps of what we currently don't have and coordinate nationally. Our role is to stimulate that activity. We're not trying to own everything. We're trying to open the door internationally. We're trying to open the door for our industry and our researchers to be able to do that—and coordinate where it makes sense—and to clearly set some priorities so that we are using our effort in the areas where Australia can achieve leadership. But that means that we really want to see the companies and our researchers in there, and we will certainly do whatever we can do to facilitate that and help them grow.

ACTING CHAIR: Which brings me to that point about competition and collaboration and that conundrum, because it's a different world now. That's a big challenge for you, isn't it? You're opening doors for companies and opportunities, but at the same time—and I'd be interested in Defence's view on this—there are certain areas where you can see the grey area between collaboration and competition, and that's something that we have to be aware of.

Dr Clark: Industry will do what industry needs to do to be competitive and will look after that. This is an opportunity. If you think about where space used to be 40 years ago—spending by government, controlled by government—we now have an opportunity where we can do things differently. We believe we can run through the legs of giants in this activity and we believe that our role in stimulating the activity around the country is going to get us there faster than holding that activity inside the agency. We see this as a wonderful opportunity for Australia to do things differently and to think about that blank piece of paper and ask the question. We're not encumbered by as much of the bureaucracy as we have been in the past, so how do we do things in a way that positions us for this new space era is a question that we're asking ourselves almost every day.

ACTING CHAIR: Thank you.

Ms Higgins: In terms of national security, Defence, through its 2016 white paper, acknowledged that space is critical for Australia's security and acknowledged the Defence Force's reliance upon space based systems. We are, however, concerned about the growing number of national security risks in space and the proliferation of some dual-use technologies that a range of state and non-state actors have been putting into space. We work with other

government agencies and we're very pleased to have a very strong relationship with the Space Agency and other agencies within Australia and overseas to ensure that Australia can meet our international counterproliferation obligations. We're doing a lot of work with other nations as well, working together on space, and we're part of the combined space operations group, which is run by the US and a number of other partners. We work together, and we're hoping to develop and do some work on norms of behaviour in space that can be shared across all governments. In terms of providing funding for industry, Mr Hodgkinson has a little bit more that he can provide.

Mr Hodgkinson: I can talk briefly to what Defence is doing in terms of supporting innovation and partnerships, including in relation to space, if that would be helpful. The 2016 Defence Industry Policy Statement included funding for two major components of the Defence innovation system: the Next Generation Technologies Fund, which was funded at \$730 million over the decade, and the Defence Innovation Hub, which I manage, which was funded at \$640 million over the decade. Both those funds seek to fund research and development in a range of technologies that are relevant to Defence, including space. Space and space-related capabilities are amongst the priorities for both those funds. The Next Generation Technologies Fund is particularly focused on science and research. The Defence Innovation Hub is more focused on technology development as we go through the higher stages of technological maturity.

The Next Generation Technologies Fund is focused on establishing a range of partnerships with research organisations and industry to work collaboratively to focus on programs of work with direct implications for future defence capability. Defence is investing through the Next Generation Technologies Fund in integrated intelligence, surveillance and reconnaissance capabilities that have space applications. Defence recently—in November last year—released a call for proposals to be part of the Intelligence Decision Superiority Research Network under the integrated intelligence, surveillance and reconnaissance priority area. So that work is continuing.

One thing about the Defence Innovation Hub relates to some of the earlier discussion around intellectual property. When the innovation hub was established it was set up with a different intellectual property framework that specifically intended to support and encourage Australian innovation. It's a different framework to that which is employed under standard Defence contracts for major procurements. For more traditional acquisition programs Defence will typically own the foreground IP that's generated under the project, but a fundamental principle of the IP framework for innovation contracts is that Defence won't seek to own the foreground IP created in connection with the innovation hub contract unless there are national security reasons to do so. We do have licensing mechanisms in there, but part of the model of the innovation hub is that for the majority of cases essentially what Defence is doing through the hub is supporting companies to further develop their own intellectual property, and we recognise that they have a stake in developing and owning the foreground IP that is created through the contracts.

ACTING CHAIR: Thanks very much for that. We have to wrap up. David, did you have one last comment or question?

Dr GILLESPIE: I have a closing comment. I'm really pleased, Dr Clark, that you have a can-do philosophy, not a can't-do philosophy, because we don't want the equivalent of local government messing up space. We want to open it up. So that's a good attitude. Long may it last.

Dr Clark: Thank you.

ACTING CHAIR: Thank you very much for giving evidence to the committee today. If you wish to provide any further information, please provide it to the secretariat. You'll all be sent a copy of the transcript of your evidence. You will have an opportunity to request corrections to transcription errors. Thank you very much for a wonderful session.

Committee adjourned at 12:17