STATE DEVELOPMENT, NATURAL RESOURCES AND AGRICULTURAL INDUSTRY DEVELOPMENT COMMITTEE

Members present:

Mr CG Whiting MP (Chair)
Mr DJ Batt MP
Mr JE Madden MP
Ms JC Pugh MP
Mr PT Weir MP

Staff present:

Dr J Dewar (Committee Secretary)
Ms N Mitchenson (Assistant Committee Secretary)

PUBLIC HEARING—INQUIRY INTO JOB CREATION OPPORTUNITIES IN QUEENSLAND ARISING FROM THE ESTABLISHMENT OF AN AUSTRALIAN SPACE INDUSTRY

TRANSCRIPT OF PROCEEDINGS

FRIDAY, 16 NOVEMBER 2018

Brisbane

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The committee met at 8.59 am.

CHAIR: Good morning. I declare open this public hearing for the committee's inquiry into job creation opportunities in Queensland arising from the establishment of an Australian space industry. Thank you for your attendance at this meeting. The purpose of today's hearing is to assist the committee with its inquiry. My name is Chris Whiting. I am the member for Bancroft and chair of the committee. Other committee members here today are Mr Pat Weir, deputy chair and member for Condamine; Mr David Batt, member for Bundaberg; Ms Jess Pugh, member for Mount Ommaney; and Mr Jim Madden, member for Ipswich West. Mr Brent Mickelberg, member for Buderim, is an apology for this meeting.

The committee's proceedings are proceedings of the Queensland parliament and are subject to the standing rules and orders of the parliament. Proceedings are being recorded by Hansard and witnesses will be provided with a copy of the transcript. All those present today should note that it is possible you might be filmed or photographed during the proceedings by media and images may also appear on the parliament's website or social media pages. The media rules endorsed by the committee are available from committee staff if required. I ask that if witnesses take a question on notice today they provide that information to the committee by 10 am on Friday, 23 November. The program for today has been published on the committee's web page and there are hard copies available from committee staff.

MURFETT, Mr Anthony, Deputy Head, Australian Space Agency

CHAIR: Anthony, thank you very much for coming to see us today. We really appreciate you coming along to be a part of this inquiry. I invite you to make an opening statement, after which we may have some questions for you.

Mr Murfett: Thank you, Chair. As you are aware, we have tabled a response which provides a broad framing for the establishment of the Australian Space Agency in response to your questions, but I thought I might take some time just to step through the Australian Space Agency, its establishment and our focus to help formulate our discussions today.

The Australian Space Agency was established by the Australian government on 1 July 2018 and we have a purpose to grow and transform a globally respected Australian space industry that lifts the broader economy and inspires and improves the lives of Australians underpinned by strong national and international engagement. That is quite a lot packed into three sentences, so we usually then explain the bits of that particular purpose statement because I think it reinforces what we are trying to achieve with the space agency.

The first part is that we are here to grow and transform the space industry itself. We are witnessing this real transformation in the sector. We are seeing technology is smaller, technology is cheaper and the cost of launch is reducing, which means that with space activities what was once the realm of government only is now a place where commercial providers can make commercial realities through space, whether that be through very small satellites, the use of space data or provisioning commercial launch, for example, which is happening overseas. There is an amazing array of opportunities which means Australia is well primed, based on our long history, to grow and transform.

The second part is growing the broader economy. In terms of the space sector, we usually use the term the 'space economy', which is used by the OECD. They have a definition which is all parts of space and its applications and implications for other parts of the economy like R&D, use of data, space manufacturing—the whole array. In the Australian context there is a real story to tell about how the use of space data can help farmers; for example, using satellite imagery to see where water has been over a 40-year period. If water has not been somewhere in 40 years, it is likely it is not going to be there for the next 40 years. It allows people to use their land better. That is one example for farmers. It can be used by our mining sector as well. The identification of minerals is another area. There are areas in emergency management which could be around managing bushfire, for example, using imagery. There is that story around space, and there is also the story that we all now walk around with phones in our pockets that use GPS and that is reliant on satellites, which is space, and some of that is actually telling that story.

The third part of the story of our purpose is that inspiring piece. Nothing inspires like space and dinosaurs. We do space. One of the things is that we have reached, cumulatively, 25 million people since we have been launched as an agency—that is, 25 million people have seen, read or heard about the Australian Space Agency. I am aware that there are only about 25 million people in Australia so this is a cumulative reach, but it shows that there is a real passion and interest in space. One of the roles of the agency is about telling the story about the implications of space, what Australia can do and help that inspirational piece so we can inspire the next generation to either be involved with space or at least get the workforce skills in science, technology, engineering and mathematics. Even if they do not continue in space and they go into other fields, those skills are going to be needed regardless of what job they have 10 to 15 years down the track.

The last bit of our purpose statement is that we have to be underpinned by strong national and international engagement. In Australia what we are doing is looking at opportunities overseas and how we create opportunities for some of the niche technologies we have and get them into supply chains. The thing about the space sector is that it is global, which is why the Australian Space Agency was established by the Australian government, because they needed a front door. Since we have had an agency in place, many of the other counterpart agencies now know who to talk to. Importantly, international companies and others that are interested in what Australia is doing in space know who they can talk to. They come to us and then we can either talk to them about our opportunities or, importantly, refer them to the right part of the ecosystem in which they can play a role. That is our purpose.

In the second part I will talk about what we are tasked specifically to do. We have now released our charter. That was published a couple of weeks ago and it outlines the governance responsibilities for the Australian Space Agency. The key things we have been mandated to do include being the primary point of contact for the Australian government in providing policy and strategic advice on the space sector, so policy advice on how we can grow the sector. The second part is about coordinating Australia's civil space sector. Hopefully we get an opportunity to explore through this hearing the fact that we have great capabilities all around Australia. One thing that was a gap was coordinating and providing that front door, so one of the agency's roles is bringing that piece together and coordinating the activities. That links into the third part of the story—that is, we need to grow the space industry. We currently have a sector that is around $4 billion in size, and our mandate is to triple the size of that to $12 billion by 2030 and grow up to another 20,000 jobs. We currently have around 10,000 jobs in the sector.

The fourth part is the international civil space engagement, so this is the international piece. Space is international and we are the front door for engaging internationally. The fifth piece—and this is a really important part, because we are playing with space technologies—is that we have a regulatory function as well in that we administer the Space Activities Act and work closely with the Department of Foreign Affairs and Trade on our international obligations. In terms of the space activities, we do operate under five overarching treaties and it is important that any space activity we undertake aligns with our treaty obligations but, importantly, the national legislation, which largely implements our international requirements. The last part where we play a role is in inspiring Australia, and I talked through how we will look to do that.

The next part I thought I would talk about for the committee is where we see some of our competitive advantages. In the lead-up to the establishment of the Australian Space Agency, the Australian government triggered a review into Australia's space industry capability led by Dr Megan Clark, who is now the head of the Australian Space Agency. I should say that I pass on Dr Clark's apologies that she could not attend the committee hearing today. As part of that work they undertook about a year's worth of consultations to identify some of the areas of Australia's competitive advantage and how Australia can grow its space industry. They were broken down into around six areas. Some of those areas include communication, technology services and ground stations. This is the communications satellite area—for example, Optus, Foxtel, NBN et cetera—but, importantly, the ground station piece. Australia has a prominent position in the Southern Hemisphere and we have a large land mass which means that we do not have our own, for example, GPS constellations but we pretty much touch on everyone else's GPS constellations, which means we have a whole lot of ground stations which are able to receive and transmit signals back up to space. As we see the commercial sector grow where there is more commercial providers, what we are seeing around the world is use of ground stations and the commercial use of those stations to communicate with new satellites that are launched. There is an opportunity there which we need to explore, so that is the first part.

The second one is what we call space situational awareness and debris monitoring. Space does not have an agreed definition, but everyone largely uses the definition of 100 kilometres is space. When we get into orbit there is a lot orbiting up there, so it means that we need to pay attention to what is orbiting around the earth. Again, because of Australia's position we can see a lot of the sky and we have facilities around Australia that play a role in monitoring orbiting objects. That was once very much in the Defence realm of activities but, again, we now have more commercial providers that are launching their own satellites which means that they need data about what is orbiting around the earth. There are opportunities for commercial provision of those types of technologies or commercial entities providing those types of technologies to Defence, which monitors those activities.

The third piece where we have an opportunity is what we call position navigation and timing infrastructure, or largely the GPS piece. I talked about the fact that we do not have our own GPS technologies, but one of the things we have and we are working on is a satellite based augmentation system. Earlier this year the government allocated around $160 million to this SBAS technology. It will bring the resolution from around five to 10 metres down to around five to 10 centimetres. What will make us world class is the next step—that is, where we have mobile reception, that will bring it down to three centimetres. Having three-centimetre resolution has huge implications if we want autonomous vehicles and drones. Having that level of accuracy is important. If we think about agriculture and precision agriculture and working out a 10-centimetre difference between where you put your seeds, for example, there are opportunities for other parts of the sector to use that technology.

The next area we talk about is earth observation services. Again, Australia does not have its own array of satellites, but one thing we are very good at is processing the data that comes from satellites. The Australian government has developed something called the Digital Earth Australia platform. I did use this as a little bit of an example earlier, but essentially it brings 30 to 40 years of Landsat data together. It compiles it. That means you can analyse it and look at changes in land form in Australia over that period of time. I explained that you can actually see where water has run for 30 years to help work out where you might want to place a property dam et cetera. Importantly, there is an international opportunity there because that is world class in how Australia has developed the data analytics and the other smarts around that technology. Other countries want to apply the base technology to their own countries, so Geoscience Australia is exploring how to get that technology, for example, to places like Canada and others. The opportunity for Australia, then, is that if that platform is taken internationally it is another way that our businesses can know a known platform and develop new applications and technologies based on a common infrastructure.

The other exciting area we talk to is around earth to space or space to earth, and this is the mining sector story. I know that I am in Queensland, but I am going to use a Western Australian example. It is applicable here. The Western Australian one is good and you will be able to draw a synergy with the Queensland environment. In Perth they manage much of their mining activity in the Pilbara autonomously with robotics and they have like a mission control type centre in Perth where they are able to manage their trucks and robotics. That distance between the two is 1,500 kilometres.

If we look at the International Space Station, which is 400 kilometres in orbit above us, we can actually take the technology in the mining sector that is looking at robotics, low lights—because they are underground—and the autonomous systems that they use and place them in space, because they are both operating in harsh environments. The middle of the Pilbara and some other areas are quite harsh and hazardous. While there is no oxygen in space, obviously, the harsh conditions and how you get the resilience of that infrastructure and technology are important and that has applications for use in space.

As we have discussions with companies overseas, they realise that is something that they are looking for. For example, if NASA is looking to build a lunar gateway, they are going to have to put in new sensors and new lighting technologies. There is a real opportunity for Australia to put some of those technologies into some large international projects. Again, we can trigger those conversations now that we have a space agency.

I have talked a lot about the downstream where we are good at the moment. There are some emerging fields that we have, because the vision of the agency is that we cannot start with now; we need to think of the 10- to 15-year horizon. We need to think about those areas where we can leapfrog into the future. That then means that we need to invest in nurturing those technologies, so that we have a role in the future. The agency needs to look at opportunities overseas, so that we can match what we are good at with where things will be in some of these space projects. Some of these space projects literally take 10 or 15 years of design. The designing is happening now for projects that will happen in seven to 10 years, so we need to get into the conversations early.

Some of those technologies include new rocket hybrid technologies, and you will be talking to Adam Gilmour later today about some of the work that he is undertaking. There are new technologies around quantum communications; you want to have secure communications in space. Australia is a leader in quantum activities. There are also our autonomous systems, our AI and others. For example, we can find that our scientists are really good at developing artificial intelligence algorithms and we can work with international partners to get our smarts on new satellites that are being launched. It is all about how we get some niche capabilities and put them into some of the larger projects that are being undertaken.

The last piece we always need to think about is inspiring future generations. For the Australian space industry to be successful, not only does the agency need to be a partner and facilitator in bringing that together; we need to inspire the next generation so that they have the skills that are there and, importantly, understand where we are going. That is a really important part of what we are doing.

I know this is a long opening statement, but hopefully it gives you a good overlay. The other thing we do always touch on is that space is not just about satellites and rockets; it is also the story of how we help precision agriculture, what we do in mining and other areas such as biomedicine and space tourism. People do talk about this.

We have companies overseas such as SpaceX, Blue Origin and Virgin Galactic that are really making inroads into space tourism. At some stage, Australia could be a place where people may wish to launch from. One of the advantages of launching from Australia is that not only do you have the greens and the blues from the sea; you have the reds from the inland and you have the greens of the rainforest. When you look at that from space, I am pretty sure it will bring a tear to some people's eyes.

There are opportunities there and it is real. Again, our role in that is making sure that we are safe, secure and meet our international obligations. Importantly, that is an area that is growing and happening. The other areas we can help in are urban planning and emergency services. Space is really not just for space; it is that space economy story, which is why we use the OECD definition, because it is a broader story that is there as we undertake our activities.

Lastly, I will give you a snapshot of what we have achieved as an agency. We are just over four months old. It seems a lot longer than that. I have said that we have reached 25 million people cumulatively. We have been around the states and territories. The head of the agency and I have spoken with many of the first ministers to understand the capabilities that exist. Importantly, we have already signed three MOUs with international counterparts. We have signed agreements with the French space agency, the UK Space Agency and the Canadian Space Agency. That is all about a high-level agreement about where the two countries can collaborate.

We have also passed legislation. We currently administer the Space Activities Act. It has been amended to really recognise that we are getting into a new area of operation with space to encourage entrepreneurship, while having the balance that we need to provide a safe operating environment. We are now in the process of developing the subordinate legislation on which we will go out and consult with industry. We have been pretty busy. We had a charter, which I mentioned we got out. It has been four months, but it seems a lot longer than that.

The last thing I should say is that the agency comprises only 20 people. It is small, but it means we are nimble and we are able to achieve a lot with the people we have. I will leave my opening statement there, Chair.

CHAIR: Thank you, Mr Murfett. Thank you for your opening statement; we really appreciate that. You talked about niche technologies and getting them into supply chains. We have discovered that there is a great ability to find those niches throughout the international supply chain and fit into them. Which niches do you think Australia is in the best position to fill?

Mr Murfett: Where we are initially primed is against those priority areas that I spoke about. We have the earth observation area. We are using data analytics. New satellites are going up. I think you spoke to CSIRO a couple of weeks ago about it now having access to the NovaSAR satellite, so there is an opportunity there.

Other opportunities that are coming up are around getting our smarts onto satellites. In that case it is AI or our sensors. We are good at developing, for example, new sensors that can detect lights, hyperspectral imaging. That is where we can place some of our technology into bigger platforms. That is where I see a real opportunity. We are focusing on talking to those other countries, understanding the projects they are going to do, coming back to Australia and getting a feel for where Australia is leading in a couple of areas.

It is only early on. We need to do a bit more work, but those are just some of the areas we see around the sensor technologies, the use of data and the provisioning of ground stations so people can access their own activities. As we go forward, we may find that our technologies evolve. We have the communication technology area, and quantum technologies is an area that is growing for us. There are new rocket technologies that we can contribute to missions overseas. There is a real array. I think we need to spend a little more time and do some more digging to specify, but I think we are on the right trajectory.

CHAIR: Australians and Queenslanders have always been very good at inventing really innovative things. We are good at coming up with some really cool stuff, shall we say. However, it is about getting those commercialised and onto wider platforms. If we do create innovative technology like the sensor technology, we need to cooperate internationally to get that technology take-up on all those satellites. Would that be a correct statement? Is that where cooperation is vital?

Mr Murfett: The way I would explain is that there are all these missions being undertaken overseas but each country and each mission will operate differently. In the European context, that is usually managed through the European Space Agency and you go through their processes. NASA, on the other hand, will largely work not with a government but with individual companies through contractual and bidding arrangements. Our role at the moment is identifying those opportunities and what are the projects that we can come back to Australia and say, 'Here is where we see some of the opportunities,' and then facilitate the engagement so that the companies can engage in those particular opportunities that are there. At the moment, the gap for us is identifying all those market opportunities overseas.

I absolutely agree with you that collaboration is central to our purpose. We highlight national and international engagement and collaboration because we need to work with partners overseas to contribute to their missions. Part of that MOU process we are developing is helping us to flesh out what those opportunities are, so that we can come back into the Australian environment and say, 'Here are some of the projects coming up and here is where we see some of the opportunities in which companies may wish to build,' because they are looking for a new sensor, they could be looking for a new O-ring, for example, or they could be looking for new robotic technology. Robotics, for example, is one of those areas where there is an opportunity for Queensland. The Mars Rover is a good example of using robotics from Queensland and how we get that into some of the bigger missions. The first part of it is us identifying the opportunities, and undertaking and starting down the journey to build on a collaboration.

CHAIR: One of the reasons I asked that question is that governments throughout Australia, including Queensland, are working with those companies that have an innovative idea to develop it and make sure it is commercialised. One of the key things we can contribute to the space industry is those processes and that support, to develop those innovative ideas into a viable business.

Mr Murfett: Yes.

CHAIR: You talked about expertise in the Landsat area through earth observation. We have developed a great capability in that area through processing and using that data. You talked about the ground stations. This could well be a great opportunity for Queensland to get those ground stations to receive and process data. Is that an area of great potential that we may be looking at?

Mr Murfett: We have excellent expertise already in the area of data analytics and the use of data from satellites. There are opportunities for Australia. I will not comment on which states or otherwise, but I think in the Australian context absolutely, because we have been doing it for a very long time. As space data or information from space becomes more applicable and we have a strong base in that already, I think that is a great opportunity. There are ways of capturing the data, linking it with supercomputers, providing the analytics and then providing all the applications on top of that. I think that is one of the areas, which is why we have highlighted that as an area of competitive advantage. It is earth observation and the use of that data to support it. That is one of the areas that the agency has identified.

Mr WEIR: You talked about the different applications with space and you mentioned everything from GPS to tourism. One of the first things that we are looking at is a site from which to launch. When you talk about that range of applications, would one facility cater for all those areas? What size facility should we be looking at as we look to the future?

Mr Murfett: When we think about launch, the first thing we look at is that there needs to be a commercial proposition. It is really for industry to work out what is that commercial market, and that will largely dictate what their requirements will be. The role that the government would play in any of the launch activity would be the regulatory role and ensuring we align with our international obligations such as the missile technology control regime et cetera.

When we look at a launch site, we have not undertaken that type of analysis. There are an array of different configurations that you could potentially have, from a multiuser site to a single-use site. Again, at the moment the approach we are taking is that the industry needs to come forward with its proposition. The things they need to work through, however, are making sure there are the environmental approvals; they have the land rights access; the flight path, for example, so when rockets take off it is in a secure area; they need to consider the air use as well, which is administered through CASA, for example. It is hard to say whether it is one site or others, but there are facilities that use essentially a multiuser site where they have a common platform where people can undertake multiple things.

The other part that needs to be considered as part of a launch is the size of the launch vehicle. The conversations in Australia are really in the smaller end of the market, which is 150 to 300 kilos. That is a smaller launch site. If you are thinking about space tourism, which is launching humans into space, that is a much larger proposition and the infrastructure behind that is a lot more expensive. Again, that is why we step back and ask, 'What is the commercial market there?' That is the proposition that needs to come forward to us.

Mr WEIR: I am not sure if this question should be directed at you, but what fuel do they use? Is that stored onsite? Do we manufacture it in Australia? Does it have to be brought in? Does it have to be piped in? Is it trucked in? How does that work?

Mr Murfett: Unfortunately, I am not a technical expert on launches and fuel requirements and how they go about it. Unfortunately, I am unable to answer that question.

CHAIR: That is something we will ask some of our experts about.

Mr MADDEN: This is really blue-sky technology that we are talking about. I was very interested in hearing what you opened with, which is the use of the space industry with regard to our farming sector, our grazing sector. That is an area of particular interest to me. The chair mentioned that in certain areas we have made a magnificent step forward in technology. I think one area where we have stuck with the traditional model is in educating our farmers and graziers and conveying this information to them. Groups like the Toowoomba and Surat Basin Enterprise put on wonderful field days and workshops. I often wonder whether that area of translation of this technology needs improvement. I realise that this is probably outside your area of expertise, but you deal with the issue of translation of information. Do you have any comment as to whether we could do this better and particularly whether the government should play a more active role in this area rather than leaving it to industry groups, individuals or even universities to play that leading role in the translation of valuable information about leading-edge technology to the people who need to use it for things like precision planting, controlled traffic and harvesting?

Mr Murfett: The first thing I will say is that it would not be appropriate for me to provide advice on what governments should do, but I will talk about the translation piece of the story. One of the mandates that the Australian Space Agency has is to tell the story about how space really impacts on the lives of people. We talked about the phone. In my previous roles I ran a program called the Cooperative Research Centres program. It has had a vast array of agriculture and farming CRCs, which have all been about the use of technology to improve beef production, working with chickens and pigs and a range of others. I mentioned that, because I think farmers have a ready appreciation of how technology improves the productivity and yield of their activities.

The bit that we need to work on now is using things that are above us that can help. I think our role as an agency is to get out there and tell that story, which is why one of our focuses is the connection with the community and how we connect with the broader community—how we tell stories. Geoscience Australia is investing in a technology that means that farmers can have the resolution of three centimetres and in the future they can be thinking about having robots that are out in the field and can plant seeds three to five centimetres apart. There are fleet technologies in South Australia where they are testing new communication satellites, CubeSats.

I will just pause to explain CubeSats. They call them a Cubesat, because they are 10 centimetres by 10 centimetres by 10 centimetres. They build them on top of each other. One cube is one U and they usually have three units above—so they are about 30 centimetres high. You can put new communication sensors on there so that you can receive signals from space. With that type of technology, you can now look at water salinity, water moisture and you do not need to be out on the land doing it; you can be on your couch. The technology is so good that you can realise, 'Hold on, I have to water the crop,' or 'I have to do other bits,' or 'There's too much salt in the ground.' It is about us telling that story—that it is accessible and it is not expensive.

The translation that we are seeing with space technologies is that it is lower cost, it is easy to get up and it is cheaper to launch, which means that we see the real potential to grow productivity through the use of those technologies. Like any other part of the R&D story, it is how we make it translatable and into a story so that we get the story out there. We are trying multiple avenues. We do Twitter—like everyone else does—but also newsletters. We try to talk as much as we can and get out into the community. We are looking to partner with Questacon so that we can communicate with the kids. If we can get to the kids, they understand and they can tell their parents what is going on. We can make it real touch and feel—that this is a real thing. We are on a journey—we are not there—but one thing the agency knows is that it is really important for us to get that understanding.

Mr BATT: You were talking about getting the GPS technology to three centimetres. How far away is that?

Mr Murfett: I do not have the exact time lines.

Mr BATT: Approximately. Is it months or years?

Mr Murfett: They have run a pilot that has shown that it works. Geoscience Australia will run a tendering process to get the broader implementation of it. It will be a couple years to get it up and running, but it is not that far away. We know it works. I will take it on notice and I will get some advice back to you on their time frames and what they are thinking.

Mr BATT: I appreciate that.

Ms PUGH: I note that one of your key tenets is inspiring the next generation. I did not grow up in a particularly technologically literate household. My children are now getting into the school system and doing STEM, robotics and coding, which is fantastic. That is just at their local state primary school. I am not asking you what direction you think the government should be going in, because I am very aware that that is not your role, but what can you see is being done well? Where do you think there is opportunity to further engage with young people, both in and out of the school system? Obviously we want kids from Australia to be employed at the Space Agency one day.

Mr Murfett: We have a lot of queries from kids. One of the things we are doing is making sure that we respond to kids to keep that inspiration. The STEM question broadly is challenging not just for Australia but internationally. How do we engage? When is the right time to engage? The Chief Scientist, Dr Alan Finkel, is leading a lot of work out of his office on advice on how we engage with kids. The Australian government is doing a whole range of programs, because there is not one part of the story. You have to start early. I think that is what we are trying to do—to get to the kids and to look at coding activities.

A couple of years ago the Australian government released the National Innovation and Science Agenda. It was about how we get kids to do coding in schools to start the process. In 10 to 15 years time, regardless of the career, it is going to need some form of technology. People are going to need to know how to use a computer. They are going to need to know how to code. Those base skills are important. Starting early is one of the lessons that has come out internationally.

The other thing that I have seen around the world is making it exciting and making it fun. I have a science background. One of the reasons I got involved is that I had a science teacher who could engage with the kids. I remember I developed a rocket when I was in year 11 or 12. That may explain why I am in a space agency now. It is about how you get involved and how you keep the engagement. I think that is really important.

They are the things that I have seen that work well. There is also our role as the agency, because space inspires. People hear about space. They get visions of the moon, visions of Mars, visions of rockets. It is about telling that story and getting a connection so that kids can say, 'Okay, that's something that I can now aim for.' That is what we want to do in STEM. The thing you want to do with STEM is have that vision about what the jobs look like so that people can work towards that particular outcome. Not everyone will go into that particular career, but if we can get the base skills I think that is an important part of the journey.

Mr BATT: You talked to the member for Condamine about launch sites. Is the Space Agency going to look at possible sites or a map or a plan of the areas that you could look at launching, or is it more businesses that are going to come along and say, 'We want to launch from here,' and then your agency has to agree with that? Which way is it?

Mr Murfett: It is the latter, because the launch has to be a commercial proposition. Businesses need to determine if there is a commercial reality and they can make a business opportunity out of it. Our role is in the regulatory piece. Anyone who wants to have a launch site and launch into space needs to have a space licence, as we call it. Then they need a launch licence to enable a launch.

At the moment, we are advising the sector, if they are thinking about a launch, to talk to us sooner rather than later so that we can talk through the requirements and how we manage our international obligations et cetera. At the moment, our view is that businesses come and talk to us about what they are thinking about with a launch. Over the next little while we are looking to be more proactive in making sure that people are aware of those obligations as well. We now have a space agency, so it is really important that we tell the sector, 'If you want to consider a launch site, there are a lot of obligations and it is not a simple thing to launch a particular rocket.' We are here to work with industry to help them achieve their aim, noting that we have to look after public safety.

Ms PUGH: You touched on some of the areas in which the space industry can work. It would not necessarily occur to people that you could use the space industry for farming or mining. Are there any potential applications in environmental preservation or working with things like climate change? Obviously we have made tremendous advances in technology and we can do all of this fantastic land mapping. Do you see any scope for working in that space at all?

Mr Murfett: Already a lot of that technology is used for environmental monitoring. I do not have the details with me, but they are able to monitor ocean currents, ocean temperatures—a whole range of different things. I have spoken a lot about the land, but I think many countries throughout the world have been using satellite data to help manage and look at climate, such as to monitor tsunamis. I talked about bushfires, because it looks at heat. There are new technologies like hyperspectral sensors that look at multiple different wavelengths. You can see a lot more in terms of what is happening on earth. There is the potential to increase the use of space technology to support those types of environmental monitoring activities.

Ms PUGH: What about things like volcanoes? Could you monitor that type of thing using this sort of technology?

Mr Murfett: Unfortunately, I am not a technical expert, so I do not think I can answer that one, but there are a lot of applications that we can do.

CHAIR: You have touched a bit on CubeSats. We have heard the term a lot. I think you made the point in explaining what they are, considering that one of the things that we will be doing in our report is talking to members of parliament about what is involved in the space industry. Can you talk a bit more about what CubeSats are, because they are one of the main tools that are being used in space?

Mr Murfett: What I might do is talk through a couple of the ranges of the satellite technologies. I will put them into three buckets. We have the CubeSats, which we call nanosatellites. They are called CubeSats because they are 10 centimetres by 10 centimetres by 10 centimetres. I think you can get them up to what they call six units, so that is six cubes stacked on top. The reason there is a lot of interest in the CubeSats is that they are small, they are cheap, they are easy to use, people can use them and because technology is now smaller it means that you can put new small communication technologies on them—small cameras sitting on them. There is a company overseas called Planet. They do not launch just one; they launch a lot in what Planet call a flock. They put 100 or so of these nanosatellites into the air and it creates what they call a constellation. They call it a flock because they call them little birds. They have a whole lot of little cameras and they go around in what we call low-earth orbit and they are able to literally now photograph the whole earth at one time in a day. Because they are small, the risk is that not all of them work—some of them will fail—but because they have so many up there it means they have enough resolution so they can do their job. The other risk with them is that they only stay up for so long. Usually they have approximately a five- to seven-year life and eventually, because they are in low-earth orbit, as they orbit they get closer and they will burn up. They have a shorter life. That is the nano part of the market.

Then I am going to go to the extreme which is the 'big birds', as they call them. These are the big geostationary orbiting satellites. It is called a geostationary orbit because it is 36,000 kilometres above us. They stay in one location. These are like the Optus satellites, for example, and they have a fixed aperture but they are really big and have a whole lot of technology on them. The reason people are going to smaller satellites is that to get a big bird up there takes a long time to build and costs a lot of money. It can take five to 10 years to build one of those satellites. Do not quote me on that; I am using that as an example. They stay there for a very long time. They can have a 15- to 20-year life, if not longer. You get that extreme. You have the nano, which can be five to seven years and you can get them up quickly but you need a whole lot of them, or you have the big one.

Then we have in the middle, which is the small satellite, which can be around 300 kilograms. Because it is bigger can you put more technology on them. You can put bigger sensors, bigger cameras, bigger communication channels, for example, and they sit a bit higher in orbit and they do

not take as long to build and they do not cost as much and are unlike the geosatellites, the big birds, which require really big rockets to get them out there. The other thing with the nano is that they require small rockets. The small ones, which is the segment in the middle, do not require the big rockets. You only need a smaller rocket to launch them. You have those three spectrums.

The market has shifted down to the nano or the CubeSats because they are cheaper, easier to build and cheaper to launch. It will be interesting to watch where the market goes with those three. Technology will continue to develop, and the disadvantage around nanosatellites is that they last only so long. Whether the market will shift into the middle area is something every pundit around the world is looking at, because they are working out launch capacity, for example, and what types of rockets they need to get the amount of satellites that are going to be needed in the future. Is it the constellation with the 100 satellites, which means a lot of launches; is it the geo, which requires one launch every little while; or is it in the middle, which is sort of the middle piece? I do not have an answer to what that market will look like, but the reason you have that interest in the nano is that it is accessible. The other thing that is good about it is that it gets kids to build them. That is the other beauty, because you get kids touching the technology.

That is the spectrum. I hope it is okay that I explained the spectrum of activity that is there. We are now watching the market for where we have that particular opportunity. We have people in Australia building CubeSats. Two were launched off Rocket Lab, which is the New Zealand launch company, on Sunday. They are now in orbit around approximately 500 kilometres. We are seeing a lot of growth in that market. It will be interesting to see what happens in the middle market. We know there is a company called SITAEL that is setting up operations in South Australia. They build 300-kilogram satellites. That is the spectrum.

CHAIR: There are niches in the market and Australia has already made some gains in the nano and mid-range market. Nanosatellites are being built in Australia and, as you said, two were launched in New Zealand on the weekend,

Mr Murfett: That is correct. We have a range of people around the country building nanosatellites—from universities through to businesses, who use them as test beds and pilots to make sure that their communication technology or their sensors actually work in space. Before putting up 100 of them, they can put up one or two to test the technology. The thing with space is that you need the hardware to work, because once it is up there it is pretty hard to get back.

Mr WEIR: Basically, the agency is a regulator for the industry. Is that a fair comment? I am wondering how many rockets are being fired up into space around the world. How do they find their position up there? I cannot imagine that different countries are firing up rockets and hoping that they are going to find their own area, whether that be further out or closer. Who monitors which ones are coming back to earth? Is that part of the role of the Space Agency?

Mr Murfett: I cannot answer all of that and who is monitoring what. I can answer the question about our role. One of our roles is as a regulator. If a company wants to launch a satellite overseas, they need an overseas launch certificate. For example, Fleet, who launched on Sunday, had to come through the Australian Space Agency, and the minister is the authorised authority to approve a launch certificate. This all comes back to our international obligations. Under the treaties that we have signed, the country is the responsible operator for all space activities, which means that the Commonwealth has the obligation for anything that we do in space, which is why there is a licensing requirement.

Also, if you want to have a launch site we need to provide a licence. That is called a space licence. If you want to launch from the launch site, you need a launch licence. We look after that regulatory part. I have talked about space situational awareness—tracking what is happening. That is monitored. If I use the US example, there has been a bit of a transition underway. Whereas previously Defense monitored and provided data to the civilian sector on the objects and where they were, the US government has now said that for civilian matters on orbit tracking the Department of Commerce, which is equivalent to our federal department of industry in many ways, is responsible. We have not thought through those particular issues at this stage.

Mr MADDEN: Has the Space Agency issued space licences in Australia?

Mr Murfett: I will take that on notice. That was one thing I forgot to ask the team this morning. For space licences we should have a space port. I will take that on notice. The focus of our activities has largely been on overseas launch certificates. I think in the period from 2003 to 2015 we had around five overseas launch certificates, but they were for the big satellites. Now we are seeing a lot of focus, from 2016 to now, on smaller nanosatellites. We have had about 17 requests for smaller nanosatellites. We have seen—not necessarily as the agency, because we are only new, but the

former team that did the regulatory part have watched this transition go from what was once the big market and now a lot into the nano bit. A lot of our regulatory activity has been around the overseas launch certificates and getting our Australian technology in flights overseas.

Mr BATT: On CubeSats, if someone needs a flock or a constellation of 100 up there, how quickly does that happen? Do you need 100 separate launches?

Mr Murfett: This touches on the question around the launch market. I will answer this probably in a roundabout way. It is probably easy to get one or two up at the moment because there are different ways to do that. They can piggyback, essentially—they call it ridesharing for rockets—where there is some space left in a rocket so they put it up there and are able to get it into the trajectory. To do the 100, that is a large volume because each CubeSat can be up to five kilos. It is a 500-kilogram payload to put up 100, so that is an own launch. Then we get into the launch schedule. This is what we are watching in the market, like everyone else is. What is the growth demand? What is the rocket schedule? If you want to launch 100, you will probably need a large amount of space on a rocket and you need to get in and get that slot in the launch sooner rather than later. Then you have the other issue that not all launches launch on time because of weather and all the other bits and pieces and that can have a flow-on. There is a market. People need to get in early and say, 'I think I want this slot,' and make sure they have enough space to put all the bits they want to launch.

Mr BATT: They can go on one rocket and then once they are up there they get into their spot?

Mr Murfett: Yes.

Mr BATT: Was the New Zealand launch last Sunday the first launch or have they been going for a while?

Mr Murfett: That was their third launch, but that was the one they called 'it's business time', where they put some business loads up there and deployed a range of satellites into orbit.

Mr BATT: How often are they intending to launch?

Mr Murfett: I cannot recall. I would have to take that on notice. It is on their website what launch schedule they are looking to do. I will take it on notice and we can get back to you.

Ms PUGH: In your submission in terms of growing the space industry you have noted the Advance Queensland fund and the Defence and Aerospace Industry Development Fund. I am interested to find out what you think are some effective government investments that have been made to get good return for investment and grow the space industry?

Mr Murfett: Again, I need to be careful how I answer the question on the effectiveness of programs so I will probably answer it by reference to some of the programs that have been effective in other sectors. In terms of some of the ones that exist, there is the Cooperative Research Centres program and there is now a defence CRC here in Queensland looking at, I think, autonomous drones et cetera. The CRC program is useful because it covers the spectrum of funding R&D that is focused on industry for up to 10 years, which means that it is focused on industry needs—but sometimes you need a lot of time to do the R&D, and I think that is an important part of the story. It is very hard to say what programs work because the innovation system is quite complex and there are parts of the market where essentially you need to look at it where there is a market failure. The CRC program offsets the risk that R&D does not always work as it should, so there is an incentive there to encourage industry and researchers to come together to work on a common challenge, recognising that it may or may not work. That is why that program is effective.

The other bit of the story is: with the earlier stuff there is always a need to fund the long-term blue-sky research as well, because you need to think about the 10- to 15-year horizon. Then you go into the industry parts of the story about how you lift the capability of businesses to make sure they have the right information and knowledge so that if they want to export they have business plans, communication plans et cetera. There are programs like the Entrepreneurs' Program that target that particular area.

The other part is: if you want to grow a sector, one of the useful things is being clear on the direction of where the sector could go. What the agency is saying is, 'We see the opportunities in these particular areas,' so that there is a clear signal to the market that there are opportunities in space for communications, earth observation et cetera.

CHAIR: The time allocated for this session has now expired. Thank you, Mr Murfett, for coming along and being a part of the hearing. It was very important for us and for the state of Queensland to hear from the Australian Space Agency. We really appreciate you taking the time to come and talk to us today. We have found it very instructive. Please pass on our thanks to the chair and the head of the Space Agency for you being a part of this.

Mr Murfett: Thank you very much, Chair.

CHAIR: We have three questions on notice and we will communicate those to you. The first one is about the time frame for when that three-centimetre resolution data would be commercially available. The second one is: has the ASA issued space licences in Australia? The third one is the New Zealand launch schedule. Thank you very much, Mr Murfett.

Mr Murfett: Thank you, Chair, and thank you, committee.

GILMOUR, Mr Adam, Chief Executive Officer and Founder, Gilmour Space Technologies

CHAIR: I remind members that the submission from Mr Gilmour is confidential. We will ask you to talk about what you can, bearing in mind that this will be on the public record. There will be a transcript for this. We invite you to make an opening statement and then we may have some questions for you.

Mr Gilmour: Thanks for having me here. I am excited that this process is happening. We started the company back in 2012. We started developing rockets in 2015. I started the company with my own money initially. Then we have had two rounds of venture capital money of $24 million. It is a story that has resonated with investors. The upstream space industry has had more than $10 billion of venture capital investment in the last six years which is a huge number. Even in Australia it is over $50 million or $60 million in investment just in the last two years—all on upstream technologies, which is launch vehicles and satellites.

I was a banker for 20 years, so I spent a lot of time analysing the market before I started the company. I did a lot of financial analysis on the industry and where it was going. We are very bullish on where the industry is going. We think the industry is going to the smaller side of the market, which is what the deputy administrator was talking about. We think the launch opportunity there is massive. There is a bottleneck in the market. We look at how many companies are out there that intend to launch satellites that have good levels of funding. We are not talking about the PowerPoint warriors who have a nice presentation and no money behind them. We track who actually has tens of millions or hundreds of millions or billions of dollars and is actively manufacturing small satellites. Just that number is 5,000 or 6,000 satellites and they are in the 200- to 400-kilogram range. As the deputy head of the Space Agency was saying, they have an average life span of five to seven years. If you think about it, on average, there is going to be a thousand of these satellites that have to go up each year and they have to go up on an independent launch vehicle because they are all in independent orbits. The frequency of the launch is going to become massive and the market is not ready for that. We are rushing forward as fast as we can to address that market.

CHAIR: Mr Gilmour, do you want to tell us a bit more about what has attracted you to Queensland and where you want to take your business? Can you tell us a bit of the back story—you have touched on it a bit—about how you created your company? I understand that you are based here in Queensland.

Mr Gilmour: Yes, I am. I was born in Brisbane. I have lived out of Queensland for a long time but I have always had a soft spot for Queensland. With this kind of technology—this is important to know—you do not have to really be anywhere in Space 2.0. As long as you have a team of talented people and a decent industry base, you can operate it anywhere. We initially came here because we were also opening up a space academy at the same place. We looked at the Gold Coast as a place that has frequent visitors, so we wanted to co-locate the two businesses. We have put the space camp on ice because we were not making enough money out of it initially and we are focused 100 per cent on the rockets. Since we have been here we have no reason to want to move. We like the location and we think Queensland is the best place in Australia to launch rockets from as well.

CHAIR: Excellent. What are the benefits of Queensland that make it attractive to launch rockets?

Mr Gilmour: When you launch a rocket you have to launch towards an easterly direction because the earth spins that way. The pickup that you get from the spinning of the earth is up to about 460 metres a second, which in relative terms is almost 1½ times the speed of sound. The earth is spinning that way really fast. If you launch that way, you get a slingshot effect. It is way better to launch east than west. The closer you are to the equator, the closer you are to having that slingshot effect take place. Once you get past about 20 degrees of latitude the difference is not much. It is only like 10 or 20 metres a second. It is not a huge amount of difference. As long as you are anywhere from, say, Bundaberg north you get a really good kicker.

The other thing is that you want a launch where there is no-one else around. You do not want to overfly anybody else's country. There are a lot of places in Queensland where you can do polar orbits, which is going north or south—but in this case you would go north—and that spins over the earth from pole to pole. As the earth spins underneath it, you can take photos of the earth. There are a lot of satellites that go into that orbit that are observing the earth. The other ones you can do are equatorial orbits, which is heading out towards the east. There is a whole different trajectory of orbits out there. You can pick multiple places on the Queensland coast where you can do polar and all the equatorial orbits. There are almost no other places on earth that have that flexibility.

CHAIR: You have talked about attracting venture capital. One of the things we heard from the deputy head of the Space Agency is that Space 2.0 is basically led by the commercial reality instead of the military reality of the situation we are in today. Part of that is finding our niches. You have talked about the advantages of Queensland as a launch site. In terms of our capabilities in other areas, what niches of the supply chain have you found that Queensland is best suited to fill?

Mr Gilmour: We are launching a suborbital rocket in the next four to six weeks. It is the equivalent of like a first stage of our orbital vehicle. We have built almost all of that in Australia and almost all of that in Queensland. When we have had to outsource parts and machining and fabrication that we cannot do ourselves, it has predominantly been not only in Queensland but in the Brisbane area. There is a good industry base here to do high technology.

The other thing is that we do a lot of collaborative research with all of the universities. We have memorandums of understanding to do research and have started doing research with UQ, QUT, Griffith and the University of Southern Queensland—I am probably missing one. Everybody has some good bits of technology and everybody is really keen to help us. One university is helping us with a catalyst technology that is embedded in our propulsion technology. Other universities are helping with high-speed aerodynamics and thermal loads when you are going five or six times the speed of sound. There is good capability here. People have worked on hypersonic vehicles here for a long, long time. We can tap into that knowledge as well. Anything we need we can get here—almost.

CHAIR: That is quite heartening to hear that within the south-east corner, where you are based, you can get the technology and also the capabilities. One of the parts we are seeing in this puzzle is that our universities are probably leading Australia in producing people who can work in this industry. Is that correct?

Mr Gilmour: I would say so. If you look at the number of engineers who are graduating out of the universities with relevant experience, I would agree with that.

CHAIR: Bearing in mind that this is a public hearing and being recorded for *Hansard*, can you tell us a little bit more about this launch that you have planned?

Mr Gilmour: We spent a lot of time working on a propulsion system. The core of any vehicle that moves is really the engine that is in it. If you look at rocket companies historically, at least 40 per cent of the development costs of any rocket is the actual rocket engine. We have spent the last two or three years developing a series of rocket engines and scaling up in size until we have an engine that is capable of generating enough thrust to take a pretty big payload into orbit. We have been testing those engines in Queensland. What we are now doing is a flight test. There is a really big difference between doing a static test on the ground and a flight test. There are probably 10 times more things that can go wrong in the vehicle and we want to gain experience in that. We are also developing a mobile launch platform so we can take this anywhere we want to, assuming we have all the approvals et cetera. That capability we are testing with this launch as well. The defence department is quite interested in that capability.

CHAIR: I can well imagine. I have a range of questions but, member for Condamine, do you have some questions?

Mr WEIR: I will probably ask the question I asked earlier about fuel—what the fuel is for those rockets and how much there is.

Mr Gilmour: We have a hybrid rocket, which is a two-phase-of-matter rocket. For our oxidiser we use hydrogen peroxide. Then our solid fuel is a mixture of fuels that is proprietary. It is kind of plasticky, you could say.

Mr WEIR: What quantity are we talking about? With a payload of 200 to 300 kilograms, what quantity of fuel would that be?

Mr Gilmour: Around 25,000 kilograms of fuel.

CHAIR: That is a fair bit.

Mr Gilmour: If you want to approximate it—and I am guessing here—it would not be any bigger than the petrol trucks.

Mr WEIR: That is about 25 tonne, roughly?

Mr Gilmour: Yes.

CHAIR: Where is the supply chain for hydrogen peroxide? How do you source that or where is that created?

Mr Gilmour: What we have we bought from a company in Germany. The good news is that we found a supplier in Sydney who is going to supply us with reasonably high concentration hydrogen peroxide. Then we are going to have to give it the final increase in percentage—up to 90 per cent or a bit beyond—with a system that we are developing. We can source it from Australia.

CHAIR: The reason I ask that is that in Gladstone there will be capabilities for a hydrogen-creating industry in the future. The Premier, as we have heard this week, has just seen the uses of hydrogen in industry overseas. That may be a capability that we can create here in Queensland. I am not sure on the process that produces hydrogen peroxide. It is a technical question about the process that is used to make hydrogen peroxide.

Mr Gilmour: There are a few ways, but the most commercial way is a pretty tricky process. It is an offshoot chemical from another chemical process, so it is like a by-product that they use. If you look at the chemical formulas, they are pretty long. There is potential to make hydrogen peroxide out of pure hydrogen and oxygen gas. There has been some technology demonstrations of that using a special catalyst. We are very interested in that because that would be substantially cheaper and it has a longer term impact. If you want to do the moon, Mars, deep space, propulsion systems and you can make hydrogen peroxide out of hydrogen and oxygen, that is fantastic. The other thing about hydrogen peroxide is that it is room temperature storable. That is a big difference in our rockets compared to almost all of our competitors who do liquid systems. All the rest of them use liquid oxygen, which is minus 180 degrees. There is a lot of infrastructure around that which we do not need.

CHAIR: We have talked a bit about the potential production of that. I really appreciate that. Sorry, member for Condamine, I will go back to you.

Mr WEIR: Are there any particular safety regulations around that above any other fuel?

Mr Gilmour: No. There is nothing different than any other fuel. You have to be careful with where you store hydrogen peroxide and you have to be careful with how you treat it. If you gave it the same care as liquid oxygen or kerosene or anything like that, you would be fine. We follow the standards.

Ms PUGH: I am interested in your view as an innovator and an entrepreneur about how governments could potentially invest in this. Obviously you have a large amount of venture capital. Are there other opportunities in the supply chain that we might be able to invest smaller amounts of capital to attract the right manufacturers or have the resources in Queensland that we need so that industries and companies like yours have what they need right here in Queensland without having to go further afield?

Mr Gilmour: My view on that is that, as much as I would love government funding—and I would definitely be trying to seek that out in the next couple of years—the thing the Queensland government can do is look at some of the infrastructure that the industry needs. Some of the things that industry would love to have in Queensland include a place to test rocket engines. We are actually working on one of those ourselves. The other thing the industry needs is a place to launch them—so a launch site. We have done a lot of numbers about how much that would cost. It does not have to be a very expensive initial set-up to start launching rockets from Queensland. That is what we would like the government to do. We think that is infrastructure just the same as a port or a train station is. If you look at all of our peer countries in the world that launch rockets, their governments supply them with the rocket launch range—on a commercial basis. We will pay for the launch if the government sets it up. We would still pay every time we launch.

Ms PUGH: Roughly how many businesses or companies do you think would benefit from that kind of set-up?

Mr Gilmour: In my submission I talk about what is going on right now in the Kennedy Space Center. The Kennedy Space Center started opening up commercial areas around the launch site for commercial operators, and that has been hugely successful. Blue Origin has set up their main rocket-manufacturing factory about a kilometre away from the launch site. That might be a slight exaggeration, but it is really close. OneWeb, which is a very large small-satellite manufacturer that is putting up a thousand satellites in the next two years, has located in that park as well. I think this is a trend that is going to continue. I think it makes sense for companies to have their activities very close to the launch site. I would have to go through my document to see exactly what we said, but we believe at least a thousand jobs would result in the next five or so years from having a launch site in Queensland—high-paid, high-tech jobs that all of these university students can aspire to.

Mr BATT: Basically, your company is going to build rockets and launch them. You mentioned a business in the US that is about a kilometre from a launch site. How far away do launch sites need to be from businesses and homes? Is it hundreds of metres or kilometres?

Mr Gilmour: It is kilometres. We have done studies on the launch sites in the United States. The two biggest launch sites in the United States are Kennedy Space Center and Vandenberg Air Force Base. If you look at Vandenberg Air Force Base, there is a township about three or four kilometres away from the launch site, and in the case of Kennedy it is about 10 to 15 kilometres away. When we have talked to FAA and NASA about what is the right number, no-one has come back with a specific number, but four to five kilometres away from a township seems to be the key.

If you look at the launch site itself, it needs to have a security zone around it—a fenced zone. I draw your attention to a launch site that is a bit further north of Kennedy called Wallops. Northrop Grumman launch a rocket from that site. The particular size of that launch site is 300 by 800 metres—the total site that is fenced. If you have something of that magnitude five kilometres from the nearest town, you are okay. The reason you can do that is there is technology in all launch vehicles called flight termination. Basically, the way that works is if the rocket starts to go off-course, you blow it up. As soon as it starts to deviate from its intended trajectory you blow it up, and you can look at videos of when that has happened. This is something that regulators take very seriously. Often you have to have it as a triple redundant system. That is why you can launch so close to population centres.

Mr BATT: At the moment in the case of local governments, which will be involved in this eventually, there is no planning scheme or approvals; it is still in the stages of working out the distances and those sorts of things.

Mr Gilmour: Yes, that is correct. We have been talking to a lot of councils about this. We have received a lot of support from councils to do this. We want to see if we can get some other government support alongside that as well. We have already done a lot of analysis about potential sites et cetera.

Mr BATT: You also mentioned a company in the states that was going to launch a thousand rockets a year. Is that what you said?

Mr Gilmour: No, I am saying I think the industry is going to need to launch around a thousand payloads per year into space, which probably needs about a thousand rockets a year. That is our calculation. That is on the lower side of things.

Mr BATT: Around the world, on average, three a day need to be going up?

Mr Gilmour: Absolutely.

Mr BATT: That is just to replace what is up there?

Mr Gilmour: It is to replace what is about to go up there.

Mr BATT: If we built one in Queensland it would be used quite regularly?

Mr Gilmour: I would say so, as long as you can attract rocket companies to come. We have actually talked to other rocket companies—some of the bigger companies—that would be interested if there was a launch site in Australia. Kennedy are trying to ramp up their commercial launches to a few a week. They want to have capacity to launch two a day. That is their goal.

Ms PUGH: Earlier you said that you can get almost everything here in Queensland. What do you see as the gaps in the supply chain for you here in Queensland? You said you cannot go over the border, so where are the gaps?

Mr Gilmour: It would be some of the higher technology stuff like the guidance system and the valves, which we source from either the US or Europe. That is very sophisticated space hardware. We basically make a make-or-buy decision, and a lot of stuff is cheaper to buy than to develop and make ourselves. It is around guidance, navigation and control systems and valves.

CHAIR: In terms of sourcing different technologies and hardware for you, in Queensland up and down the coast and in regional areas there are companies in the mining sector that have developed innovative technologies and are experts at remote mining as well. Are there links between your industry and the mining industry? Is that something that we could encourage to perhaps help fill those gaps for you?

Mr Gilmour: Not in the short term. I think in the long term, if you look far out in the industry—if I can make reference, last year three major US investment banks did research reports on the future space industry where they talked about $1 trillion to $3 trillion. I do not know if you have heard about that. All of them mention off-earth mining as a potential revenue source. It still is a little bit speculative at this stage. However, at least one of them said they did not take that into account and if they did it

would be $20 trillion of annual revenue. The deputy of the Space Agency said it is 10 to 15 years out. That is where I think it is going to be. We want to be involved in that; we want to take these systems to where they want to go with our vehicles. It is more that distance out than anything that is in immediate need right now.

CHAIR: Certainly in the long term the future for space mining is an incredible opportunity for Queensland. In the short to medium term I am seeing there has not been that much liaising with those mining companies who are producing their own technologies to work in very harsh environments. It may be there is a parallel development of equipment or hardware that you may use. I see that there is no real linking with the mining industry to see the technologies they are using now.

Mr Gilmour: We have hired a software engineer from a mining company, so we have a decent idea about the kinds of systems they use. There are some similarities in terms of real-time operating systems, where there is a split-second decision process that is in the software. We can replicate some of that from the mining industry, but that is also being developed independently in the space industry, in aerospace.

CHAIR: That brings me to another point. In Queensland and Australia we are experienced in those technologies that process information, whether it be software or working with data that comes down for Landsat. Is that something that you see as a great opportunity? That is obviously outside the launch capabilities that you have talked about. In terms of the space industry, do we have the capabilities to develop the software and process the information that is delivered by satellites?

Mr Gilmour: This is out of my real expertise, but I am aware of the industry and I am optimistic about that. I think industry is also a bit like Space 2.0: if you have good ideas and good technology you do not really have to be anywhere, so there is no reason Queensland could not excel in that as well.

Mr WEIR: In your introduction you made comment that a number of satellites go up and you said the market is not ready. What do you mean by that?

Mr Gilmour: It is the launch vehicle market. What has happened in the industry over the last 20 or 30 years is there have been a number of companies that have made reasonably large launch vehicles that can take, say, 10,000 to 20,000 kilos to orbit. For some reason that I still cannot understand, they have all kept going in that way. If you look at SpaceX, Blue Origin, Arianespace, Northrop Grumman and NASA with the SLS, they are all building these vehicles that can take 40, 50 or 100 tonnes to orbit. I think everybody thinks everybody is going to the moon really soon and hoping to get a lot of business. However, what has not been developed until just recently—rocket labs are first—is the small-launch vehicle market. You have seen this trend in satellites where they get smaller and smaller, but the rocket industry was slow to catch that trend. This is why I am saying there is a bottleneck, because all these satellite companies are busy making all these satellites and the small-launch market is not ready yet. We are still two years away from being able to launch. There is probably only another two companies that will be able to launch in the next 12 to 18 months. By the time it gets to 10 launch vehicles, it could be five years away, so there is going to be a big bottleneck.

Mr WEIR: The Australian Space Agency was saying it would be predominantly commercially driven. What you are talking about is what industry is looking for—they are looking for the smaller rockets—but the actual manufacturers have not progressed to that stage yet. Is that what you are saying?

Mr Gilmour: Yes, I am. There are a lot of companies that are trying to develop launch vehicles. There are probably 20 or 30 companies around the world that are having a good go at developing launch vehicles, but the process takes a long time. It takes five, six or seven years to do and the realisation in the market has only been in the last two or three years that this is a good business to go after. That is why there has been a bit of a technology lag. It is hard to build a rocket—very, very hard.

Mr WEIR: That is why you are saying that we need a facility where you can actually test the rockets?

Mr Gilmour: Absolutely, test the rocket engines and then test fly the rockets as well. That is part of the process.

Mr WEIR: So there is a little bit of work to happen in this space yet?

Mr Gilmour: Yes.

CHAIR: You said that the opportunity of having a test rocket engine facility to test those engines would be quite a useful bit of infrastructure. What exactly does this facility need?

Mr Gilmour: We have actually developed a facility like this already in the Scenic Rim. We are putting it through council approvals right now. It is capable of testing quite powerful rocket engines and a whole lot of little ones as well. It needs to be in a reasonably remote location. It needs to have infrastructure set up where you can bolt a rocket engine on it and it will not fly that way. We have a huge concrete block and a whole lot of steel and places to lock it down. It is a little bit like testing a big jet engine—similar thrusts. Then there needs to be some infrastructure around that like sheds et cetera to do assembly and final check-out. The only other thing you need is a container or a building that has all the fluid systems in it because you pump liquid and liquid oxidises in the rocket engines generally—unless you are testing solids, in which case you do not need any of that infrastructure; you just need the concrete block and the test stand, and then you strap it on and give it a go.

CHAIR: Obviously you have an exclusion zone around it of, say, a kilometre or 1,500 metres?

Mr Gilmour: Yes.

CHAIR: What kind of noise does that generate? That would be quite enormous.

Mr Gilmour: It is pretty noisy. It is about 130 decibels. It is pretty similar to a jet engine.

CHAIR: I was about to say it would be similar to standing next to a jumbo jet taking off.

Mr Gilmour: We have tested it, and from 300 metres it is about 110 decibels.

CHAIR: You have your own facility, but the state government is helping to provide infrastructure that could cater for a number of different companies or opportunities; is that right?

Mr Gilmour: We would be happy to look at everybody else using our facility as well. If there is a limited amount of money to be spent on investing in the industry I would rather it go to the launch site, because that is what nobody has.

CHAIR: The launch site has received a lot of attention from the media. It is good to generate publicity. There are obviously confidential negotiations and talks. You have spoken a bit about launch sites. Bearing in mind we are in a public forum, where along the Queensland coast would make a good launch site? Can you expand on that a bit?

Mr Gilmour: It has to be reasonably remote. We obviously do not want to launch right next to a community. It has to be near the coast so you can launch over the coast for range safety. It is good to have road access for a rocket. Some sites do not have good road access. It needs to have power and internet. The other thing we have been looking at is airspace clearance. As soon as you go north of Brisbane you are out of a lot of airspace. That is what is good about coastal Queensland, because there are not a lot of aircraft flying over. Four or five kilometres away from a town in an area where we can have 300 by 800 metres squared would be good. It does not have to be super complicated.

CHAIR: We have heard about issues flying over the reef or sea lanes. Is that a factor?

Mr Gilmour: I do not think so. Rockets are very precise vehicles. They can blow up and things like that, but you can have a very good determination of where your rocket is going to go. You can do an analysis of where your first stage is going to land. There are two things that will happen: either your rocket will launch and it will malfunction and you will have to terminate it, and then whatever is left will fall to the ground; or as it goes up into space the stages fall away. Our vehicle is a three-stage vehicle. Most other vehicles are either two or three stages, so somewhere up on the way to space the stages fall away and hit the ground. You can analyse trajectories and you can even modify your flight inclination to make sure that your rocket will not land on the Great Barrier Reef. We have done that analysis already. I would think that, using probability analysis, there would be about a one in 10,000 or 100,000 chance of anything on our vehicle or a similar vehicle hitting the reef. The other thing you have to look at is what is in the vehicle. What are the fuels? Our fuels are not toxic. They do not have any nasty chemicals at all. Oxygen peroxide dissolves into water and oxygen, and our solid fuels are like plastic. The rest of our vehicle is basically carbon fibre, so this is not a nasty thing that is going to fall into the ocean and pollute everything anyway.

CHAIR: Have the maritime authorities been involved? Do you need to clear a path for seaborne traffic underneath?

Mr Gilmour: Yes, you do. You would need to clear a path for seaborne traffic.

CHAIR: What kind of time window do you need to have that clear?

Mr Gilmour: It really depends. It can go anywhere from 30 or 60 minutes to four hours. The launches from Kennedy often have one- to four-hour launch windows, and they will clear 24 nautical miles—I would have to check that—in an arc around the launch site.

CHAIR: It is more of an arc than a lane?

Mr Gilmour: Yes, it is a bit of an arc just in case. That is what you have to do.

CHAIR: What has been your experience so far with the maritime authorities here in Queensland?

Mr Gilmour: We have not talked to them yet.

Mr BATT: You mentioned the government being involved in the launch site and that most launch sites are government owned. We have heard about a new one in New Zealand that is owned by private enterprise. Is that the new way it is going, or is that just a one-off?

Mr Gilmour: I think it is a one-off. Rocket Lab got a tonne of money. I think they spent about $20 million—I am guessing—on that launch site. Peter Beck, who is the CEO, has come out and said he regrets doing that. It was not a good commercial decision. I do not think that is a good investment for a single company. The thing about a launch site is that it is like a railway station or an airport: it is not going to be used by just one company; it is going to be used by many. It is not a good idea that one company pays the money for the launch site. If I look at my investable dollars, I do not want to invest dollars in infrastructure; I want to invest in technology and hiring smart people and developing world-beating technology rather than launch sites, which is more infrastructure stuff.

Mr BATT: If you have a launch site run by the government where private enterprise comes to launch their rockets, the fuel for each of these rockets can be made separately by each of those businesses for their own needs?

Mr Gilmour: Yes.

Mr BATT: They bring that with them?

Mr Gilmour: They can, yes. There are not a lot of different fuels. You would probably need kerosene, RP-1, LOX, liquid oxygen, hydrogen peroxide and maybe one more. The launch companies can be responsible for bringing that and storing it.

Mr BATT: That would be part of it, though. You would need a place for that to happen, rather than a fuel tanker or a petrol station that you can fuel up with the same fuel that everyone uses. That is not how it works.

Mr Gilmour: That is a concept that you could have. If you go to the NASA sites or any of the US sites, they have big storage tanks full of LOX and RP-1 and so on. There is liquid hydrogen as well. You could have places where you would store it. When we talked to our hydrogen peroxide supplier they advised us to remanufacture and concentrate the hydrogen peroxide at the launch site, so we would probably do that.

CHAIR: The fuel aspect is important because, as we know as legislators, it triggers different regulations. Having said that, as legislators we have had a lot of experience in regulating that as well. In terms of creating fuel, we have gone into the biofuels industry as well, so it may be that this state is in a position to help out or create that particular niche.

Ms PUGH: You were talking about opportunities in space mining. Are we able to use the same mining equipment, the drill bits and things like that? Can we use the same things in space that we use on earth? What potential opportunities are there and what can we mine in space?

Mr Gilmour: In terms of what there is to mine in space, the initial commercial opportunity is water. Water is fantastic in space because you can make rocket fuel out of it, you can drink it and you can breathe it. Most companies that have started up to operate space mining have just looked at water. Beyond that there are all of the metals and minerals that we have here on earth. One of the interesting things is that if somebody figured out how to get an 800-metre-diameter asteroid with water, minerals and metals in it to orbit at a low-earth orbit so that you could do all of your in-space manufacturing from the one place, they would be an trillionaire. That is the future I see in the next 10 to 20 years.

I did not fully answer your question. You will not use exactly the same kinds of tools. One of the problems that you have is that there is not a lot of gravity on a lot of these objects, so you have to kind of suck onto it. You can still use drill bits and all that kind of thing, but it is not exactly the same. We take it for granted because we live on a big-gravity world here. We have machines that dig, they are really heavy, and they use their weight to pull up the material. You do not have that on the moon, Mars or on asteroids, so you have to have different systems.

CHAIR: We have heard that there is a great degree of cooperation in the space economy amongst the commercial players and regulators. A high degree of cooperation is one of the benefits that the sector has. Can you describe the level of cooperation amongst all the players that you have experienced, especially here in Queensland?

Mr Gilmour: I think nobody really shares technology, but people are happy to share experiences and what went wrong. They are very encouraging and people are willing to help each other out. There are a lot of technology companies—we are trying to decide if we are going to do the same thing—but they make technology for their own vehicle and they think they can sell it to other companies to use on their vehicles, and that could be a beneficial thing. There are a lot of businesses sharing ideas and products and the community is very friendly. When you go to a space conference and you talk to people in the launch industry, they are all very friendly. They talk about some of the issues they have had and you all learn from each other. I was a banker for 20 years, and it is very different.

Mr WEIR: You said that when a launch goes wrong it is terminated. I assume that happens very early in the launch; is that right?

Mr Gilmour: It can. I have not done a statistical analysis of exactly when they fail. From what you see of launch failures, a lot of them are in the first 10 seconds of launch. There was a Russian launch two or three weeks ago that failed after about 100 seconds, but it is generally in the first stage of the flight that it fails.

CHAIR: There being no further questions, we will now close this session. Thank you very much, Mr Gilmour, for coming along and sharing with us today your points of view and your knowledge. We have a great line-up today, and we really appreciate you coming along and being part of that. There are no questions on notice.

Proceedings suspended from 10.42 am to 11.02 am.

NIKOLIC, Mr Blake, Director, Black Sky Aerospace Pty Ltd

Mr Nikolic: I am the founder and director of Black Sky Aerospace and, amongst other positions, I am also the founder and director of Australian Rocketry and the president of Beyond Blue Aerospace Inc.

CHAIR: I invite you to make an opening statement, after which committee members will have some questions for you.

Mr Nikolic: Thank you, honourable members, for the opportunity to speak here today. I have a diverse background in information technology, pyrotechnics and explosives, and aviation as a former Army pilot. The culmination of these, combined with my passion for aerospace, is what brings me here today, representing a leading aerospace manufacturer and supplier, Black Sky Aerospace. Although Black Sky Aerospace is a start-up, our leadership team brings a rich history from a diverse range of fields which has created an unprecedented capability in the aerospace and defence sectors.

As highlighted in my written submission, the Australian government's establishment of the Australian Space Agency has been a positive and much needed step towards the future of Australia's involvement in a rapidly growing ecosystem. For the industry to thrive, though, we must look at all aspects as if it were a puzzle, knowing that one missing piece could be crucial to overall success. This includes launch services, covering launch sites and launch vehicles.

Some of BSA's services include launch vehicles, propulsion systems, telemetry and consultation to industry and government. Australia has a small industry compared to the USA and Europe. I use the term 'collaboration' in my submission. However, I do not think this correctly identifies what we need for success. I have evolved this into co-creation so that Black Sky Aerospace along with government, strategic partners and customers can share the challenges, risks and successes together. In the past, Black Sky Aerospace has facilitated other aerospace and rocket companies by way of providing components, access to launch sites, airspace and insurances. Black Sky Aerospace intends to continue supporting other aerospace companies that have aligned their goals with the best interests of the industry.

Black Sky Aerospace primarily manufactures in Queensland, with all integration happening in Logan. Working closely with other Queensland companies such as Laser Central and PFi, we have been able to increase job capacity through strategic alliances and keep resources local. Whilst we aim to keep the core supply chain in Queensland, the space industry is global and Black Sky Aerospace has had to expand rapidly with the creation of Black Sky Aerospace LLC, a limited liability company in the USA. This is to meet the requirements of DARPA, the Defense Advanced Research Projects Agency, which is a part of the US Department of Defense, and their Launch Challenge program. I understand that Black Sky Aerospace is the only Australian owned company that has prequalified for that program. In addition, Black Sky Aerospace has an agreement with Equatorial Launch Australia to build, operate and launch Queensland developed technology at the Arnhem Space Centre in the Northern Territory. It is anticipated that these programs alone will create growth of up to 30 or more Black Sky Aerospace staff over the next few years.

On the topic of orbital launch sites, it is possible but not practical or economical to achieve almost any orbit from any location. Equatorial Launch Australia has been proactively setting the stage for what I expect to be the first operational orbital launch site in Australia. As the name suggests, though, their focus is on equatorial launches. In South Australia, Southern Launch is working on launch site capabilities in the Great Australian Bight and, again, as the name suggests, their focus is on southern or polar launches. Queensland, which consumes the majority of the east coast of Australia, has a number of advantages for an orbital launch site but also challenges. I believe it would be beneficial for Queensland to have a launch facility, but ultimately all sites have pros and cons and the long game should see them complement each other, depending on what service and/or orbit is required.

Whilst it is good to aspire to big dreams, we need to be realistic and determine what is actually beneficial for Queensland and ultimately Australia. We should not compare ourselves to NASA, which has been around for 60 years and has had access to over half a trillion US dollars. Large operations such as SpaceX and the United Launch Alliance have also been around for over a decade and have had the ability to piggyback off existing infrastructure and billions of dollars in cash and resources. Like all rocket companies, their triumphs have not been without heartache and lots of money. Their successes, however, are commendable and continue to be an inspiration to budding rocket scientists around the world. Their capabilities, however, are extremely large and, in my opinion, beyond where we should be aiming at this point in time.

With a decreasing footprint and a shift to constellations of satellites, the market and demand for small-satellite services is going to increase. Just last weekend, as others have touched on, Rocket Lab USA, which started in New Zealand, launched their first fully commercial payloads into orbit. Only a few years ago, New Zealand was in a similar position to where we are right now. With an investment of $25 million from the New Zealand government, in this short period they have achieved realistic and beneficial goals and the company is now valued at over US$1 billion.

I believe that these goals, which will benefit farmers, mining and remote communications, are more advantageous and sustainable to our state of affairs. At this early stage, an investment like that from the Queensland government would create significant advantages for companies like Black Sky Aerospace to further develop technology and capability and open up the launch market in the Southern Hemisphere. Fortunately, we already have some capabilities for suborbital launch, and Black Sky Aerospace operates the only commercial suborbital launch site located in our own backyard in regional Queensland. This site allows Black Sky Aerospace to develop, test and operate systems and vehicles, whilst boosting the economy in regional areas.

As you would be aware, I am excited to announce that next Wednesday, 21 November, Black Sky Aerospace will be launching Australia's first commercial launch vehicle using one of our subscale Sighter190 sounding rockets. This launch will be carrying three commercial payloads from Hypersonix, ACSER—the Australian Centre for Space Engineering Research—and Dekunu Technologies. The purpose of this flight is to demonstrate process and capability, whilst being completely transparent.

With a global market worth approximately US$360 billion seeing exponential growth, Queensland and Australia will naturally benefit by companies like Black Sky Aerospace supporting the ever-growing satellite market and beyond. The benefits of launching our own rockets include demand of and revenue into local supply chains, ease of international regulatory burdens and decreased turnarounds. Again, through co-creation with our strategic partners and customers we will see continued advancements for our variety of technologies, providing real data and sustainable jobs.

Just before I hand back to you, there are a couple of points raised earlier that I will touch on, from other questions that you have asked. In regard to links to mining, there is a massive crossover. Our robotics guy in Black Sky Aerospace is involved in a lot of mining aspects. His claim to fame is that he developed part of the science lab that is on *Curiosity*, which is sitting on Mars right now. It was designed to take soil samples from Mars, so there is a big crossover there with mining. Again, because of the harsh natures, the testing for robotics and putting things into remote environments, there is a massive crossover.

With regard to sea clearances for launch and the like, with the DARPA Launch Challenge that we are involved in, a lot of what we have to deal with is actually the risk analysis. We have a heavy focus on things such as debris. When a rocket launches, yes, it is true that you can predict where the rocket will land or where it will go and where the boost and things like that might fall. However, if there is an anomaly or the vehicle breaks up, a lot of the process is actually defining and determining where those parts and components will fall. Two nights ago I did a webinar from 3 am to 8 pm with DARPA. One of the slides that came up, which I took a photo of, was about the ship hazard area. Without going into the statistics now, I would be happy to share that information with you, which gives you the actual requirements. That is part of the US Defense and the FAA, which is the equivalent of CASA in the US.

CHAIR: Certainly we can take that as a question on notice, about the information you have on risk analysis for seaborne traffic.

Mr Nikolic: Sure.

CHAIR: Blake, can you describe a bit more about the process and the importance of being prequalified for DARPA? It is something we have not heard about in our hearings so far. We would love to get some more information on what it is, why it is important and how you do it.

Mr Nikolic: Sure. With the Launch Challenge, DARPA is looking for the rapid deployment of orbital launch vehicles. They are looking at a range between 10 kilograms and 1,000 kilograms. They are not being exclusive. If someone is capable of only extremely small satellites versus the large satellites, they will tailor it to suit what the companies can actually provide. The importance of that, especially for us, is that it is forcing us to go through the channels of space licensing with the FAA and also with the US Department of Defense. They have recently come out to say, direct from the Pentagon, that they have an issue with foreign companies being involved. This is why we now have the Black Sky Aerospace LLC. It is actually a US company, that we own, that is handling and managing that process.

That aside, it is quite important because what they are achieving or aiming to achieve is what has been happening in the US for decades and where we are about to step into in Australia. It is a foot up for us to be able to say we can be compliant with the US regulations. For example, in New Zealand, when Rocket Lab launches their orbital vehicles, their airspace is actually controlled by the FAA. New Zealand handed over that responsibility to the FAA.

CHAIR: The FAA is the—

Mr Nikolic: The Federal Aviation Administration.

CHAIR: In New Zealand?

Mr Nikolic: No, in the US. The US FAA looks after the airspace during a Rocket Lab launch. That is not to say that that would happen in Australia, but it is something that we need to be wary of because of those treaties that have been discussed in the past. Once you go above that 100-kilometre zone you are in the international space treaty area, and there are a lot of other little idiosyncrasies that come into play.

CHAIR: DARPA is the Defense Advanced Research Project Agency and, as a company, you attain a status with them; is that correct?

Mr Nikolic: Yes, so you have to go through a series of processes to apply. You initially register, which anyone can do, and then once—

CHAIR: That is with the American Department of Defense?

Mr Nikolic: Yes, and then once you have done that you then put forward your case for how you are going to actually do the challenge. If they approve that you then go into prequalification, which is where we are now. The next stage is qualification. The process for that is that in two weeks time we have to submit a submission to DARPA which they will sign off on. Then on 15 February we have to have acceptance for a space licence submission to the FAA. That is the point when we will become qualified. Then we have to carry on with the program to actually launch vehicles in the US.

CHAIR: Just to clarify that, that is an agency in the US and you prequalify and then qualify with them to be a rapid response launch provider?

Mr Nikolic: Yes.

CHAIR: In terms of the commercial aspect, it is obviously quite a bonus or a boost to have that prequalification or qualification?

Mr Nikolic: Absolutely. For us it is an acknowledgement that what we are doing is real and is being accepted by organisations that have been doing this for a long time. I quote from one of the DARPA webinars that we have been identified as 'not one of the crazy ones'.

CHAIR: That is probably their technical term?

Mr Nikolic: Yes.

CHAIR: What investments from government would benefit you? You have talked about us being involved in it there. In a nutshell, what are the investments government can make that would benefit you?

Mr Nikolic: The obvious one is investing in organisations, which would be amazing. However, it becomes tricky who you invest in and what you invest in et cetera. Going back to the discussion about launch sites and infrastructure, that is probably a major component for the Queensland government to look at—something that can benefit the industry as opposed to an individual.

That investment would be able to facilitate things like testing. That is a lot of what we actually do, but it can upscale those processes. As we continue to develop our systems, we need more infrastructure like that for testing. If the launch site came to fruition with the government owning that or an organisation that is run by industry as opposed to an individual—and when I say 'individual' I mean company or person—owning that, those are the sorts of investments that in the early stage would help kickstart a lot of the industry for Queensland.

Mr WEIR: Staying on the subject of the launch site, we have been hearing about different sized rockets. How would you envisage that facility being used for different scale rockets? Would it be different launch sites in the same gathering or can you make one facility to do the whole thing? How would that work?

Mr Nikolic: Using foreign launch sites as a foundation for what we are doing and also for what Equatorial Launch is looking at, the ideal is to have multiple launch pads which would take the vehicles. A couple of reasons that comes into play are that it increases the capability of launch and

there is a quick turnaround. You might have multiple vehicles needing to be set up at any one time. Recently they had SpaceX and ULA do a launch on the same day. If they had the one pad that would never be possible or viable.

SpaceX—it is good to refer to them because they have a lot of history—had an issue on the pad during testing where something ruptured and the rocket blew up on the pad. It had nothing to do with the actual launch; it was just during the testing phase. That destroyed the pad and it was down for months. If something like that was to happen and we only had the one pad, you could knock it out for a long time. Ideally you would have multiple pads within the same region. How that is spaced out all depends on the location and the site. Having more ability at the same time is better.

As I mentioned in my introduction, looking at the likes of these bigger launch companies you find that they have a niche market for massive satellites going to geostationary. I think we need to focus more on the smaller launch providers, which is where we and Rocket Lab fit into, especially in the early stages. When there is already a set-up to do those larger launches, someone who is paying hundreds of millions of dollars to launch does not want to sit around for a maybe to do that. They have a provider for that already. Our focus should be in that smaller market to allow rapid turnaround. Plus it is much easier for the infrastructure to be put in place.

Mr WEIR: From what you were saying about taking into account shipping and so forth, that would also affect the location along the coast?

Mr Nikolic: Absolutely.

Mr WEIR: Did you have any broad ideas? If you are not going to say where it should be, would you say where it should not be?

Mr Nikolic: I have my personal opinions on things and then there is also the aspect of keeping people happy. To me the reef is outright a no-go zone. If every rocket worked fine that would be great. I will not ever be putting a bet on that.

When we go through this process we have to come up with what we call the debris catalogue. That debris catalogue is for every piece of the vehicle that may break up—whether it be due to an anomaly or a flight termination. We have to look at every trajectory, every altitude, every speed that this thing is doing and where that debris may land. We go through a Monte Carlo process, which can take days to run on supercomputers, to find out what that debris catalogue is and how it is going to affect things. If you get one large piece that lands in the ocean, you might be able to go and pick it up and that is great, but if you do not how do you then accommodate all those fragments that may have landed somewhere? Ideally, in a perfect world you do not have that, but we have the reality to deal with.

Things like the reef are no-go zones. We have the J route, which is basically from Cairns down to South Australia, which is one of the busiest routes in the country for air traffic. It is a case of avoiding things like that or being able to work in areas that minimise that air traffic, sea traffic, tourism or whatever it might be. There are a lot of things that come into play to be able to determine what is going to be a suitable site or what simply will not work. It is a very big question with a lot of components. There are a lot of aspects to it. We consult with others to assist them to try to find those locations that may or may not work.

Ms PUGH: A key theme that we have been hearing throughout the hearings is that a lack of launch site is a problem for businesses to progress. It seems like a lot of people are saying we really need to be looking at investing in a state sponsored facility rather than asking it to be done by private enterprise. You have also mentioned the $25 million investment. It is very helpful that you have put a figure on that. Could you expand on how you would see that $25 million figure being used and invested to grow the space industry?

Mr Nikolic: There is a possibility for private enterprise to run these sorts of things. Equatorial Launch is one of those. They have a particular business model which I am sure will work well for the Northern Territory and what they are doing. The benefit of the government doing it is that you have co-creation—you have different industry representatives all having a part of it. Whether it would just be for launch or for maintenance or other services, there is a lot of benefit that comes from investment into that side of things.

We currently do not have access to a launch site. As the sites like ELA come on board there will be access to launch sites from Australia. However, each site has its pros and cons. Each site has its limitations. While the Equatorial Launch site is fantastic, it is difficult to do other launches which may have to come over populations or over other countries. It is the same with the southern launch site.

If we are talking purely about Queensland, the investment into a facility assists with the issue of where those other launch sites may exist but cannot do particular orbits or do particular services. Queensland can have the opportunity to grab that. Cooperation with all the launch sites means that everyone grows together and everyone benefits together.

The $25 million investment from the New Zealand government that I mentioned was into infrastructure and the site. I am not exactly sure whether any of that money was into the company itself, but it was into the company's infrastructure. That is exactly what we are saying. Put the money into the services or the infrastructure that is required for all of these companies to operate and that way everybody involved in the industry can benefit.

Mr BATT: I want to ask more about the Equatorial Launch site. You said you have a contract to launch from there?

Mr Nikolic: Yes.

Mr BATT: Some other witnesses have talked about that site being less productive because it has to go over other countries or other places. Can you explain how it works up there or the issues they would have?

Mr Nikolic: The site is based in Nhulunbuy in the Gove peninsula. There is actually a clear path for them to launch out to the north-east, so above the tip of Queensland and below Asia and the like. You can technically hit any orbit from any location, but whether it is viable economically or practically is the question. People do not want to spend more money than they have to. This industry is not cheap at the best of times. People are trying to save on those sorts of expenses when they can.

The Equatorial Launch site is designed for equatorial launches along the equator. It has the advantage of being so close to the equator. They have a massive opportunity for those launches and they are clear for their proposed orbits to do that.

One thing that everyone focuses on is orbital. Everyone has forgotten that to get to orbital there is a whole section before that. One of the benefits up at that site and what we do at our launch site is the suborbital side of things. It is not just about that orbital market. If we are looking at the coastline of Queensland it really is an orbital site because, in terms of the suborbital side of things, whilst you could do some testing into the ocean, you really cannot go backwards over populous areas. I do not know of too many areas where there would not be populous areas somewhere flying west.

Up in Nhulunbuy you have the area south into massive open areas. Where we launch out west, again, there are big open areas. Farming communities are great because they are hundreds of thousands of acres of nothing. The equatorial site has the huge benefit of it being clear up through to the equator. Queensland will have opportunities to go north and south. It depends on the requirement of the customer or the orbit that needs to be achieved.

Mr BATT: How far off is the equatorial site from its first launch?

Mr Nikolic: Very close. I do not want to put a figure on it as such. It has been in discussions for many years. I have been consulting with them for many years. They have gone through the environmental studies. There are a few trivial things that need to be achieved and launches will start there. Initially it will be suborbital launches. It is not too far away.

Mr BATT: Suborbital launches is what you are doing on your launch site?

Mr Nikolic: Orbital is up and around the earth and suborbital is up and back down. One of the prime benefits of suborbital, which is not ultimately where the satellites go, for our business model is to actually assist people in testing out their gear. Anthony Murfett stated that you need it to work because once it is up there it is hard to get back. That is exactly it. A lot of the space junk, as it is referred to, will be the satellites that go up and do not work. It is something floating around and waiting to burn up in months or years. What we do is provide people with the ability to test these systems. Part of next week's launch is exactly that—testing some sensors and GPS units so that when they progress into satellites or other vehicles they are going to work, because if they do not it is a lot of money to spend for no return.

Mr BATT: You said that you have three businesses on your payload to go up next week.

Mr Nikolic: Yes.

Mr BATT: How does that work? It goes up. It is tested in the atmosphere and then it comes back down again? It lands?

Mr Nikolic: Yes, we will recover the three payloads. They have different requirements in what they are trying to test, but we will recover those payloads and return them to the customer so that they can then analyse the data and see whether there are things that they need to improve on, or it worked, or whatever might be the case.

CHAIR: That is a really good description of what we will be seeing on Wednesday. For the record, can you describe to the committee what the launch is about on Wednesday and what you will be achieving?

Mr Nikolic: Sure. As I mentioned, the launch and why we are inviting dignitaries is, firstly, for transparency—demonstrating that there are processes and safety protocols. We have a lot of scrutiny from regulators, whether that be explosives or CASA or other regulators. Because of how the industry is forming, there is a lot of maybe misinformation but education that needs to be done so that people can physically see some of the steps that are taken for this to happen.

On top of that being the first commercial launch, as we are claiming, is the fact that we have those payloads on board. I will give you an example. Hypersonix has developed a ceramic carbon panel that is designed to handle hundreds or thousands of degrees. When a hypersonic flight happens, they will be going into excess of mach 5—five times the speed of sound. For this flight we will be doing only a bit over mach 1. The idea is not so much for the temperature right now but to prove that the temperature sensor, the ceramic panel, works. If they have any issues with the data logging, it is far more economical and easier to fix now before we start moving into those hypersonic flights.

When you go beyond the hypersonics and we start talking about orbital launches, we are talking in excess of mach 24, so these things need to travel at seven kilometres a second. All of these sensors need to work as they progressively get higher. It is nice to put them in a vibration testing room or do some other testing, but until you put it through its paces it is hard to determine that it is going to work.

Apart from the transparency, the processes to demonstrate all of those, it is to legitimately have some customers test out their equipment so that they can then continue to develop. The AXA GPS unit that we are using is a unit that they do now or intend to continue putting on to satellites. For the ability to get some long-range testing—telemetry—and also that it is working as required, it is very important for their future progress to be able to have these fly on satellites.

CHAIR: Thank you. That is a good description of the payloads that you will be taking up. Can you describe in particular the vehicle that we will be seeing on Wednesday?

Mr Nikolic: Sure. This is our subscale Sighter 190 sounding rocket. It is almost five metres long and 190 represents the diameter—so approximately 190 millimetres. It is designed to go up and down. As I said, it is suborbital. For the propulsion system on board, we use a proprietary solid system. The rocket itself is just a single stage, but we develop these vehicles in up to three stages. We could go more if needed. The motor that we use is not just beneficial for us as a launch vehicle but also, being a solid, it can be used as a booster to assist other companies and other rides.

Currently, solids are still very well used. They have been going orbital since the 1960s. The Vega rocket is an orbital solid. The Minotaur is a five-stage orbital—up to GO, in fact. The easiest one is the shuttle. The program is now cancelled, but they had the two outer tanks—the white SRBs, which are solid rocket boosters. It is the same fuel type that they use as what we are using. The liquids then take over, because the lower atmosphere is quite dense. It is hard to get through and the performance of a lot of liquids or other vehicles is challenging. Using the solids to get them up that first stage is really beneficial. We have the ability to assist and facilitate others with that, but our core of what we are working on is to use those solids to go into orbit with a three-stage configuration.

CHAIR: Certainly, as you said, what we will be seeing on Wednesday will go up and come back?

Mr Nikolic: Yes.

CHAIR: What is the mechanism that you use to control the ascent and descent?

Mr Nikolic: With these vehicles—and I quote NASA—they are inherently safe because we are not using control systems. When we start talking orbital, yes, control systems come into play to be able to guide them. Control systems can be challenging, because if something goes wrong they can go out of control. Because we do not use control systems on these suborbital vehicles it means that we can predict the trajectory, the landing zone, a lot easier than with control systems.

We will not be controlling the vehicle at all. Once it launches it will do its own flight path, but through our simulation modelling we will be able to get within a very close accuracy of where the vehicle will travel and where it will land—so where we need to pick it up.

CHAIR: How is the landing process? Is it parachute controlled? I am not quite sure how the return aspect happens.

Mr Nikolic: Sure. We have a range of different mechanisms. This particular flight is what we call a close proximity recovery. The idea is that, at apogee, which is its highest point in flight, it will deploy a drogue parachute, much like a skydiver will. That drogue makes the rocket fall rapidly, but it is unstable, because we do not want a ballistic trajectory. Once it reaches a particular altitude—a lower altitude of about 1,000 feet—it will then fire a main parachute, which will land the rocket safely.

Ms PUGH: Like straight down?

Mr Nikolic: It will land on its side.

Ms PUGH: Once the main parachute is deployed, it comes straight down? It is more controlled; is that right?

Mr Nikolic: Yes. You do not want to deploy main parachutes too high, because then you have atmospheric conditions that can make it drift. With this one at the lower altitude, with the rapid falling, naturally the atmosphere will help slow it up, but when the main parachute comes out it will slow it down to try to not damage anything, because you still want to give the customer the payload. It will drift just a small distance from that point.

CHAIR: Okay. Excellent.

Mr BATT: In relation to the launch, where the rocket goes up, do you have to control that whole space? Do you have a lease of land? How does that work for these suborbital launches?

Mr Nikolic: We have access to a site, which is a particular area. Beyond that, we will be governed by CASA for a cylinder of airspace. Exactly like how aircraft operate day to day, we use the same rules. There are slight caveats for rockets and launch vehicles. We have to remain within that cylinder. In that cylinder there may be properties or communities with people. Within that cylinder we need to identify where the rocket is going to fly and where it is going to land, and then we will do our risk analysis to see what is the likelihood. I hate this terminology, but it is correct. They use CE, which is the casualty expectancy. You need to have that to whatever the requirements are to make sure that you are not going to—

Mr BATT: Cause casualties.

Mr Nikolic: Cause a casualty. There are a lot of terms that are scary, but they are just what they are. We have to go through that risk analysis to determine what is the likelihood of the vehicle doing some damage and then, through our risk mitigation, mitigate that risk.

The vehicle itself will land somewhere within that cylinder. That cylinder might be on a neighbouring property. We communicate with the properties around, or where we think it might go, about what is happening and what is going on.

Mr BATT: 'Can I have my rocket back, please?'

Mr Nikolic: Something like that.

CHAIR: Thank you for that. I wanted to make sure that we had on the record what we are doing on Wednesday. We appreciate that.

Mr Nikolic: Sure.

CHAIR: I want to return to the issue of manufacturing. You have said that your manufacturing is happening here in Queensland and you have an integrated chain in the Logan area. Can you describe in particular some of the things that you are making and give an example of where you are bringing in people, technology or opportunities around the Logan area?

Mr Nikolic: We are based in Logan. Other manufacturers we bring in are Laser Central and PFi, who happen to be a stone's throw from each other. That is to manufacture certain components. In-house we have capabilities that have a limit, and beyond that it is not worth us trying to invest into machining or equipment to do that. In-house we do a lot of fibreglass manufacturing, the assembly of componentry and the like. Our lead avionics guy is based in Victoria. He does a lot of the work down there but we communicate a lot. Whilst you would love all the expertise to be in Queensland, it is not practical. We will manufacture a lot of the vehicle and integrate the assembly and all of that inside our workshops.

The propulsion system is probably the most interesting of all at the moment. We are in the process of getting some licensing to manufacture the propellant onsite. My background is in explosives and pyrotechnics. I could not tell you how many licences I have for import, export, testing, manufacture—the whole lot—in different states around Australia and overseas. At the moment, a lot of the propellant is manufactured in North America—the US and Canada—and we import that for the vehicles. This particular flight will have one of the motors that we have manufactured in the US and brought in for it.

There are a few challenges that we need to overcome to be signed off for that manufacturing, but once that is done that supply chain remains local. Some of the chemicals that we require may have to be sourced from overseas. It depends on availability and whether anyone in Australia is making them. Often there is not, because there is not much of a market for it. The propulsion system, ultimately, is going to be manufactured in-house. Of the vehicle itself we do a lot of the manufacturing in-house, except for certain components where we use those companies like Laser Central and PFi. A lot of the avionics is developed in Victoria, but then when it comes up to Queensland we will integrate it with other systems as well. It is a wide variety.

CHAIR: It is probably accurate to say that most Queenslanders would be surprised by the amount of technology, hardware and equipment that you can source locally and embed into your systems. There is a really good capacity in Queensland for high-precision manufacturing. Would that be correct?

Mr Nikolic: Absolutely. Beyond that—and I think Nick Green from PFi mentioned this in his hearing—there are the ma and pa nuts and bolts shops that do not know that they could sell a part that could be put into an aerospace vehicle. It is not just into the vehicle; there are the stands that we have to support the vehicle and there is other ground support equipment that is required. A lot of people and companies would not be aware that they might have a product that suits.

Mr BATT: I want to go back to the launch side of things again. I have my local government hat on again. Do you have to get approvals from the current local authority, under planning schemes or anything like that, to do your launches? Did you have to go through those processes? Are there any authorities that you have to get approval from when it is suborbital?

Mr Nikolic: Yes and no. There are a lot of authorities that we deal with—for example, CASA and the explosives regulators. There are federal and state. With regard to the council, we are on privately owned land so technically no, but as a good citizen we work closely with the councils and whoever we can to communicate what we are doing and get their involvement. Logan City Council is very supportive of what we do and Goondiwindi Regional Council is also very supportive. It depends on where you are located and what you are doing. Often there is not a requirement, but we still work with them anyway to make sure that everyone is happy and everyone is aware. Again, as I said, we are all about transparency. If there is something that we are doing and it needs to be addressed then let us address it. We do not want to try to sweep things under the rug, because in the end it is going to bite us.

Ms PUGH: I would like to go back to when you talked about the debris from aborted missions or failed missions over the ocean. You said that you would not want to be near the Great Barrier Reef for that reason. I wonder how we can clean up any kind of debris, whether or not it is on the Great Barrier Reef. My thinking is that, as we become more aware of what we are dumping into the ocean and what is in the ocean, increasingly there will be a community expectation that it might be removed. What is the feasibility of removing debris, understanding of course that you could have big bits and little bits?

Mr Nikolic: That is a fantastic question. A lot of this comes down to the testing of equipment to try to mitigate those things. By mitigating issues such as potential debris it means that you will potentially limit that happening. If it does happen—touch wood it does not but it is a possibility—it all comes down to what it is and what the vehicle is. The way we manufacture our vehicles could be completely different from the way that someone else manufacturers a vehicle. It is a difficult question to answer.

When we do stages, we will be deliberately dropping things into the ocean. In those stages, though, in our designs we will attempt to recover those. Whether it be through flotation or something like that, the ability to get that back to reduce junk is hopefully greatly increased. If a vehicle does break up, though, again it is a difficult one to answer. If it does happen, in my mind that is why you want it to be in an area that is probably not as affected. These things settle on the bottom of the ocean and life goes on. You do not want them settling in coral or where things are protected or are very sensitive to foreign objects.

Ms PUGH: To follow on from that, would it be possible to manufacture your equipment in such a way that you do not have unrecoverable debris dropping into the ocean?

Mr Nikolic: From our perspective, our aim is to recover all debris on a nominal flight. It is only an anomaly that would potentially cause that issue. From our perspective, we intend to recover 99.9 per cent of everything.

CHAIR: The time allocated for this session has now expired. We have one question on notice about the risk analysis for sea traffic. Could that be provided by 10 am next Friday, the 23rd?

Mr Nikolic: Sure.

CHAIR: Can I put on the record that we are now operating as a subcommittee. Thank you, Mr Nikolic, for what you have shared with us today. We look forward to seeing you very early on Wednesday.

Ms PUGH: Actually I do have one more question. Would this be a suitable thing to bring a six-year-old boy to, by any chance? I am thinking about driving myself out and bringing Heath. I think he would think it is great.

CHAIR: It is a long trip.

Ms PUGH: I know; I just checked. It is four hours and two minutes from the city.

CHAIR: I think we will probably have that discussion on flying there.

KINNE, Mr Peter, Regional Director, Australasia, DigitalGlobe

CHAIR: I invite you to make an opening statement, after which committee members may ask you some questions.

Mr Kinne: Thank you for the opportunity to speak to the committee today, and I look forward to your questions. As I stated, I am from DigitalGlobe International. I am also the company director for DigitalGlobe Australia. My role in DigitalGlobe is part of the Maxar group. The Maxar group includes four subcompanies of which DigitalGlobe is one.

I am not sure whether any of you have heard of Maxar or DigitalGlobe before, but I will give you a short explanation of what the company group does. SSL are based in the US. They built the Sky Muster satellites for Australia. They build a lot of satellites. That includes satellites for other companies and our competitors in other countries of course. They also build satellites for our own company group, and those satellites in future orders will include things such as WorldView Legion, which is a constellation that goes up in 2021.

Another part of the company group is MDA. MDA is famous for building robotic arms for space shuttle missions and international space stations. They also build the Radarsat constellation, which is Radarsat-1; Radarsat-2, which is currently on orbit; and the Radarsat Constellation Mission, which is a mission for the Canadian government. The thing about radar as a constellation for observation is that it can see through clouds. It has some wonderful applications in change detection. It is a type of satellite that sends down a chirp and as a result it can measure that chirp coming back. If something changes on the ground, the chirp changes so it can be very clear about what has changed on the ground. It can report on subsidence. We have an asset that is 800 kilometres in space, but it can report on subsidence to a level of four millimetres. These are the kinds of things that we can leverage from space. It includes subsidence in mines. We are reporting on a mine in Queensland at the moment which has subsidence issues. It is used for tunnelling projects. It is also used for monitoring deforestation around the world.

MDA as a company also builds satellites. Part of the Maxar group is working on how to get rid of space junk. I heard that come up before. We are looking at how we build our satellites so that they are serviceable, because most satellites when they break down or run out of fuel become inoperable. How do we make those satellites now so that they are serviceable in orbit? That is one of the areas of focus.

Another part of the group is Radiant, which is high-end analytics. My understanding of what this company group does—it has 6½ thousand employees so I do not know what everybody does—is international weather reporting and forecasting; crop analysis and reporting for governments around the world and futures markets; and human geography so different countries can understand what is happening in other countries.

Then there is DigitalGlobe. I am not sure if you have heard of DigitalGlobe before. I am not seeing any nods.

CHAIR: No.

Mr Kinne: We own and operate the highest resolution commercially available satellites. We have five satellites in orbit that go down to 30-centimetre resolution and they orbit in a range of about 600 to 760 kilometres up. If you are talking about a satellite that can measure 30-centimetre pixels from that distance, the telescope or the lens on the front of the satellite is quite huge. We have what we would call the big satellites, not huge ones. Our satellites range from 1.6 tonnes to 2.7 tonnes. Those assets typically are in orbit for at least seven years but it can be for up to 15 years.

You will have used our data, absolutely. Our data is on your phones. When you look at Apple maps and you look at the image, that is coming from our satellites. Google, Apple and Microsoft have huge agreements with us to supply their data. Imagery is only part of what we do, because the way the satellite collects information it collects it as data. It collects it as numbers. We know with each sensor that that particular sensor with that value will be a colour like green, but what we do is we tend to cut the wavelengths up into small bands and we can analyse each band against each other, so we can tell you the difference between a tree and a green roof of a house, for example.

That has led us into some pretty exciting projects around the world. If we look at what we are doing, we are creating an analytics environment where it is more about the math than it is about the maps. Does that make sense?

CHAIR: Yes.

Mr Kinne: I think it is important to cover that, because that is where the benefit is in looking at what we are going to talk about, which is really a focus on ground stations.

There are five satellites currently on orbit from a DigitalGlobe perspective, and MDA owns and operates Radarsat. Those satellites have various spectrums from RGB, which we are all familiar with—we see in RGB: red, green and blue—right up to 16 channels, which includes short-wave infra-red. A really exciting part of it is the various wavelengths. I do not know what motivated somebody to find this out, but there is a channel between the colour red and visual/near infra-red, which is called red edge. Red edge is very specific because it reflects off plants that are undergoing photosynthesis. If you see a plant that is green and it is not reflecting in red edge then it may be poisoned, dead or whatever. We can actually tell the health of a plant from space. We can tell many things about the ground and what is happening on the ground from our sensors.

I will give you a little bit of background on that. DigitalGlobe took all of its historical data from its five satellites, which is about 100 petabytes—that is a lot of zeros—and it loaded that into cloud based systems and created a platform. All of our data is now available in a cloud platform.

CHAIR: Publicly available?

Mr Kinne: We are a commercial company. Is it publicly available? At a fee, yes. We are Nasdaq listed. We are also dual listed on the Canadian stock exchange. We are a commercial company so we have to make money. That is life. With respect to that, it gives us the ability to open that data for massive analytical projects.

I will pause there and tell you a little about my background. I graduated just over the road at QUT with a science degree. I did a masters at Griffiths in business, and I spent many years as a data scientist in CSIRO. At various stages in my career I made it into remote sensing. I hold a position on the space advisory committee to the Queensland government. I am also on a committee for the regional development association for Brisbane. I have a volunteer position as an ambassador for the foundation for DigitalGlobe, so we assist with research and development and we give them free data usually to help them with their projects. I have a role on the spatial industry diversity panel to make sure that our industry keeps up with the trends, and I am Queensland chair of the remote sensing and photogrammetry commission. I wanted to give you that background because there is a lot beyond the technology that I think will benefit our industry here in Queensland.

My role in the region which I manage the business for includes Australia, New Zealand and the Asia-Pacific countries. In two weeks time I will be in Suva for a conference where we assist the remote-sensing industry over there. In those areas we have done a lot of work with identifying maritime borders, food security and disaster responses. Cyclone Pam was done in collaboration, triggered by a partner in New Caledonia. The information was collated by me, and we were covering that event and delivering the emergency response imagery within something like two hours of the orbit—the same day. We also did Tropical Cyclone Marcia when it came through South-East Queensland. We were supplying the emergency response to that as well as disaster damage reports. We leveraged an international crowd for that. We did citizen science to identify where all the damage was, and we were doing damage reports back to the Queensland government within a 24- to 30-hour period.

Within Australia we have been involved in some unique projects. To labour the point on how we can use this information, we have partnered with a company in Canberra called PSMA. With that company we have delivered a project where we have identified every building in Australia—7.6 million square kilometres and over 15 million buildings. It is the first time a continent has ever done this. There have been cities such as Singapore, which is 750 square kilometres, but to go and do it over 7.6 million square kilometres has never been done. It is the first time in the world anybody has ever done it and it was done here in Australia.

Apart from that, because of the multispectral nature of our satellites, we are able to identify every tree, the height of every tree, the size of every tree, where the grass was, where the driveways were, how big the roof is, how high the roof is at each eave as well as the complexity of the roof, whether the roof has solar panels or whether the building has a swimming pool. All of these metrics feed into a very rich dataset to help businesses make better decisions. Obviously, the applications are very strong in the insurance industry as well as in telecommunications in rolling out 5G networks. Those are being leveraged right now. This is stuff that is happening that I guess would not be in the windscreen of most people to see what is going on.

The reason I think I was asked to come along today was my interest in pursuing ground stations for Queensland. There is an opportunity here. Australia has limited commercial infrastructure compared to many of the developing and most developed nations. If you look at the ground infrastructure in our neighbours up north, there are ground stations for all sorts of satellites throughout Asia. Even Thailand, India and countries that we would consider perhaps even developing nations

are having ground stations, because they see the value in it. The thing about Australia is that we typically have not made that investment. We may have made the investment for a large international constellation such as the European Sentinel Copernicus program or the American US base Landsat program, which are typically around 10-metre to 30-metre resolution, but we have not gone into the commercial side of things. We seem to have left that for everybody else to do. Because there is none here, that is where there is an advantage to become a first mover for the Queensland government.

The benefit is in the partnerships. It is not just in creating a satellite park; it is about partnerships and it is about looking at the whole value chain. When we look at and talk about ground stations, we should interpret that as ground stations, data centres, innovation hubs or clusters, some R&D component, the commercialisation of that, and looking at the industries that can be improved or impacted by that the most, which is, of course, agriculture, mining and the environment—key industries for the Queensland economy, I believe.

South-East Queensland from an industry point of view already has for one reason or another—historical perhaps—a natural cluster of remote-sensing companies that can leverage these technologies. They are based in Toowoomba, on the Darling Downs and around Brisbane. From my observation in the industry, there are more of those companies in South-East Queensland than there are concentrated in any other capital or any other state. From my observations, we have a natural cluster.

When we look at how we leverage these technologies, we should not be just looking at what we do locally, because once you become part of this value chain and you create algorithms or create processes or benefits to agriculture, the satellites do not hover over Australia for long; they are everywhere. That same technology, that same development, can now be leveraged with companies both nationally and internationally. We are talking about being able to scale our industry and take advantage of state, national and international opportunities. I think that is where the real benefit is for employment.

One of the benefits that I think we can start looking at is with ground stations, because these companies can already get the data. They can come to me or my partners. I have a series of partners in Australia whom they can purchase through and they can buy that data. However, when we flip into an environment where you have ground stations and those are commercially operated within Australia, we can switch to a much faster response rate. For example, if somebody wants to look at frost damage within a particular region, at the moment we would require that commercial order to happen 24 hours prior to the satellite coming over, at a bare minimum. Typically we would want it to be much earlier. If we have a local ground station network, we could be looking at turnarounds much more frequently than that to place the order, because you are buying satellite minutes; you are buying access to that satellite in that orbit. You have the ability to task, download and distribute that data within that same orbit environment. It becomes a very fast response and gives you access to, I think, benefits not only in agriculture but also in emergency response—the whole series of responses that the government may want to partake in.

Another point that I would like to make is the threat. What is the cost if we do not do it? This space is moving very fast. This is about machine learning and artificial intelligence. If we do not do it, if we do not partner with local industry and we do not create that environment, that ecosystem, it is likely that those solutions will be developed overseas. You can already see the hub of activity that is happening in Europe and the US and how there is a lot of support for those through both venture capital and government support. You can see that if we do not do something in Australia—and I hope in Queensland—we are going to be in a position where we become purchasers of overseas technologies. That is the threat.

Among that threat is that the benefit to us—and I would reflect on this traditionally—is that in my industry an inquiry would come in and somebody would say, 'I want to do a project that involves this sort of process,' and no-one would say no. They would say, 'Yes, we'll do it.' They would work out how to do it. There was always time to be able to get your knowledge together, to find the expertise you need, to do a bit of research and maybe work out how deep you had to do something. My observation around the world in this space is that companies are focusing on one very narrow function and they are doing it very deep, they are doing it well and they are attracting an international audience.

I will give some examples. When we did the rooftop identification for Australia—the 15 million houses—we had a look at several different technologies and we settled on a small company out of a university in Canada. The company name was Ecopia. Still to this day, we believe that Ecopia makes the best building rooftops. At the moment, that is all they do—building rooftops. You think, 'How bland?' but they have grown from a garage to many floors of a building now because they are doing international work for building footprints around the world. They will branch out into other things, but

it is finding that particular niche that Australian companies do well and do deep and do so well that people will come internationally to get their results from those companies. I think that is the opportunity.

Why should we have it in Queensland? Queensland, particularly South-East Queensland—from Toowoomba to the north coast of Brisbane—offers an ideal location. The location gives it a good view to the horizon and the cone, or coverage, of the view of the satellite as it comes into that orbit extends across the whole eastern seaboard of Australia out to the middle of Australia. It also extends into the Pacific and up to Papua New Guinea. An antenna at the right place in South-East Queensland is commercially extremely valuable to our mining, our agriculture, our Great Barrier Reef surveillance—a whole bunch of different opportunities for our businesses to leverage.

When I speak about ground stations, ground stations such as a DigitalGlobe ground station are the same technology that can be leveraged by Radarsat and by our competitors. Obviously, there are different components that let it talk to the different satellites, but the main infrastructure piece is a transmitter that will cover any different assets.

CHAIR: They could rent that out to download or upload? A company can book to use that asset?

Mr Kinne: Yes. There would be a priority, a tasking level, and if it gets too busy you put in another antenna. That would be a good thing. Obviously, there are opportunities to put antennas in different places. South-East Queensland, as a first step, gives you coverage. Putting another antenna somewhere else in Queensland gives you redundancy. It is not to say that there is not an opportunity to put antennas somewhere else. I think the main employment is not the antenna, though, even though we are focused on that. The main employment is that whole ecosystem. It is the data centre, the analytics hub, the cluster, the R&D, the commercialisation and servicing our local industry or international industries.

In closing, I would like to say that the future is going to be a lot more satellites up there. This is not going to be a question that goes away. There is a first-mover advantage. If New South Wales, for example, puts in a downlink, or a ground receiving station in northern New South Wales, it will erode the commercial viability of one that is in Queensland. There is a first-mover advantage that needs to be taken into consideration. I think there is a huge amount of support from the industry and the different companies within the industry to work out how to partner to do this.

CHAIR: Thank you very much, Mr Kinne. That was quite impressive and very detailed. We have heard a lot about launch facilities and infrastructure. You are focusing on those ground stations and you include data centres as part of those ground stations; is that correct?

Mr Kinne: If we talk about ground stations, we have to talk about the ecosystem, which is data centres, creating innovation hubs or clusters of companies that participate in it, and being able to get the economies of scale from these small companies into almost a single focus to be able to build that part of the economy, yes.

CHAIR: It is a ground station. It is a download and upload facility. Are they the best kinds?

Mr Kinne: The objective would be to get the upload and download, although that is not always essential. Sometimes you can leverage other ground stations around the world to upload, because the uploading of your tasking is very small compared to the data that you are going to collect.

Another thing I should mention is that the reason we have to download is that the amount of data we collect is massive. The satellite memory bank fills up. We have to empty it. When we talk about the large-format satellites like Landsat and Sentinel, Landsat is 30 metres. Every time you halve the resolution, you quadruple the data. You are going from 30 metres down to 30 centimetres. We cannot have the satellite always open. It is a commercial operation.

CHAIR: This is an aspect of the space economy that has not had as much focus as other areas. From what I am hearing, there is a lack of those ground stations within Australia and there is a great opportunity to have those?

Mr Kinne: Absolutely.

CHAIR: South-East Queensland has some natural advantages which make it a great place to create a ground station; is that correct?

Mr Kinne: That is correct.

CHAIR: No-one has been the first mover for that in terms of jurisdictions around Australia?

Mr Kinne: I am very aware that there are other states that are thinking about it and having a discussion about it. I am sure there will also be some ground stations put in by the Department of Defence. These are not going to be commercially available. We are talking about commercial.

CHAIR: We have talked about cluster promotion. What kind of assistance can a government provide to make sure that we are the first mover?

Mr Kinne: I do not think that is a five-minute answer. I feel sure that from the outset the discussion at the moment about setting up a satellite ground station park, having some input into how that is structured. I think there is a second component to that—that is, providers like DigitalGlobe are not going to feel comfortable or are going to be more likely to go and commit to a ground station when there are long-term contracts. It is not a 'build it and they will come' scenario. There is a fair investment involved. We would look at what contributions are being made by governments and other entities to put the thing in place and then what is ongoing. You do not want to have a ground station and then starve it of data.

CHAIR: You need the long-term contracts with government departments and other users?

Mr Kinne: Yes.

CHAIR: Locally based users of your products?

Mr Kinne: I think I am sometimes going to get to a boundary where there is detail I should either take on notice or should perhaps not answer, if that is all right.

CHAIR: That is absolutely fine. We are very sensitive in this inquiry about what you are able to share.

Mr Kinne: I feel sure that there are follow-up meetings that we can arrange where we can certainly provide a lot more detail on how this would happen.

CHAIR: In our report we will talk about ground stations and how we can initialise that in Queensland. There are opportunities for companies to cluster around this particular station or be a part of it?

Mr Kinne: Absolutely, to leverage the data that comes off it. To partly answer the previous question, there is a retail value for data and that retail value for data is set based on what generally happens around the world internationally, and that is how that data value is set too. Once you go into a commercial data environment with a ground station, the metrics change. You are not necessarily purchasing a small piece at a time; you are buying the satellite minutes. You are buying an economy of scale, so the economy of scale affects how people can get access to that data. That means that a lot of these small companies can scale better, because sometimes the cost of the data is prohibitive to some of the projects, given that the ground station environment and the commercial access may actually open up a pathway for a lot of this data to be, I guess, accessed easier and more affordably.

The other thing is that when you do go into these environments there is some suggestion that the satellites are used more efficiently. We are collecting for the Googles and the Apples and various other customers around the world in a certain way. If you were collecting for the state of Queensland, would you collect it the same way? Would you collect it a different way? The data might still be useful to DigitalGlobe to still provide to its international companies and customers, but would you collect it a different way that makes more sense for the state? Those sorts of questions come onto the table and you get greater efficiencies again.

CHAIR: In terms of government assisting to create a ground station, would it be in terms of infrastructure or help in facilitating the building of the facility and the technology that can be downloaded and distributed, or is it perhaps providing long-term contracts to help attract players?

Mr Kinne: I think it is a bit of both. It is supporting the building of the infrastructure and then it is enabling longer term contracts that form the basis of the bulk purchasing and that will drive the commercial interests.

Mr BATT: You mentioned that these satellites need to be tasked before going out to get information. With the 15 million rooftops study, the satellite does not just go out and take photos and then you say, 'We need to go and find out how many rooftops there are. We will go back and look at it'? You actually task that to be done before?

Mr Kinne: It is a bit of both. There are about 45,000 square kilometres of cities and towns in Australia. For all those cities and towns, absolutely we task fresh imagery—cloud-free, beautiful imagery. Over the cities and towns in Australia we needed to have the most current, up-to-date imagery. Particularly consider the south coast of Queensland out to the west, where the amount of growth is significant. For the areas that are in the centre of Australia we have a rolling collection and update program which is cycled over years which is maintained by the satellites in particular conditions and we look to making sure that we have a seasonally adjusted, nice, complete image of Australia on a regular basis. We are doing our best to make sure that we provide that as frequently as possible.

For the cities and towns, the cut-off was 200 head of population. For the cities and towns with 200 people living there, according to the census, that was all freshly collected and had elevation models and everything done fresh. For the whole of the rest of Australia the problem was that we did not know what we did not know and nobody could tell us where the houses were so we had to look through every pixel to find a rooftop. That is a huge effort. For that we were not going to go and take a lot more imagery to collect the desert to find no houses, so we had a KPI on currency. We stuck with that KPI on currency and we were able to cover Australia within the KPI and work out where the housing is. When you think about it, there is not that much change in those remote areas. We are looking at it for farmhouses and farm buildings. The rate of change is very small. That is how we completed it. It was a bit of both.

Mr BATT: Even the height of the roof? You task all that beforehand so it works all that out? Again, you do not go back through imagery?

Mr Kinne: That is right. When we are looking in the remote areas of Australia, once we stepped out of those cities and town areas we were not doing the roof of every house in those areas. We focused on the dense population areas. The job to go and create an elevation model for every rooftop in Australia outside of the cities would take years at this point. The technology is changing.

Mr BATT: Do we have many government departments now that use your company?

Mr Kinne: Absolutely.

Mr BATT: You were talking about the forestation area down to 30 centimetres. Is that in agricultural areas?

Mr Kinne: No, you guys—

Mr BATT: We use someone else?

Mr Kinne: Yes, you use somebody else. I would like to provide you a better solution.

Mr BATT: It sounds like a good solution.

Mr Kinne: Between the two, the radar and the optical, it gives you a very good combination of solutions. The current service that you have is based on a small-sat environment. They send up 100 satellites the size of breadboxes and they have the ability to have daily revisits and daily data. The downside is that the imagery is between three- and five-metre resolution. If you wanted to count cars or you wanted to look at the line markings on the road—some of the projects around the world include doing the line markings and chevrons on all the roads, major highways, in some countries. You cannot count cars with five-metre data; it just turns into a blur. When you are talking about 30-, 40- and 50-centimetre data, the opportunities to get a very clear understanding of what is on the ground are much better. When you are looking at the multispectral side of things, our satellites do have that depth of resolution. We measure resolution in what is the pixel size, what are the number of sensors that are in the satellite—red, green, blue, near infra-red, red edge, coastal blue and short-wave infra-red. That is the resolution as well because it builds you a data stack over that particular area, and also the number of times of revisit. When you look at the spectral depth of our products they give you a very clear understanding of where a tree is and where it has gone. I think that is an advantage that the Queensland government could leverage.

Mr BATT: Tasking for a car count or a pool count for local government: that actually is done by the technology? You do not just take the photo and someone has to go through and do the count?

Mr Kinne: No. I will give you an insight. When we started the geoscape project with the PSMA we actually did use people. We used the crowd. When you use machine learning you have to get a training dataset, and we were using the crowd to create the training dataset. Then the computer would work out the algorithm to match the training dataset and then we would put that back into the crowd and the crowd would correct the computer and then the computer would have another go and then the crowd would have a look at it again. We have done that for two years.

Two years later, now we will not use the crowd. The computer is that much better than the crowd. You think about swimming pools. In the first iteration we did of swimming pools automatically by algorithms we were 40 per cent correct. We are supposed to be a lot better because the algorithms are internationally recognised and published. Our experts said, 'That can't be right. Only 40 per cent?' It was over Sydney. I said, 'When did you take the image?' and they said 'August' and I said, 'August is our winter—pool covers.' We basically did not get a water reflection because of pool covers and empty pools during winter.

Machine learning has been able to craft that all into its algorithm and now it finds empty pools, pools covered by sun shades, pools with covers, pools with green bottoms—all that sort of thing. It is the same for solar panels. Think about it: you are looking down at a swimming pool and you are

looking with a sensor that only has RGB. Our sensor that looks for swimming pools has 16 different wavelengths it is looking into short-wave infra-red. It is going to see differences that you cannot see. Then it is going to learn from that. That is how we train it.

Back to the vegetation question, if you want to know the difference between a tree and a grass it is easy for you, because you know that grass is short and trees are big, right? But a palm tree is grass. When the satellite looks at the wavelengths it is going through and can tell the difference between trees and grass. Our satellites, with their different sensors, can actually determine the many differences between green trees, green grass and a whole bunch of things.

That is how we are doing food security in the Pacific. We work with the secretary of the Pacific Community, and some of the work we are doing there includes looking for things such as breadfruit. In the small island countries, if they do not find enough natural food in the environment the risk is that people will migrate to the capital. If they migrate to the capital then they are going to be on government food handouts, so how do we make sure that people stay in their communities? We make sure there is enough food in those environments to survive. That is one of the projects that we do: coconuts, breadfruit and a whole bunch of plants and trees.

Ms PUGH: Very briefly, in recommendation No. 2 you said that we need to be wary of all-encompassing labels of areas of competitive advantage that do not provide sufficient specificity. Am I right in thinking that what you are saying here is: if we are looking to invest in the future of the space industry we need to pick specific areas and be quite deliberate about that, rather than try to be all things to all people? Is that what you meant by that particular part of the recommendation?

Mr Kinne: I will answer the first part of that question. I think you are referring to the bit where I was talking about the companies at the moment when they scale. They need to find something that is particular to our industry and gives them commercial gain locally. They need to do that very well, such as finding a way of monitoring compliance in mines or whatever that happens to be. When they do that very well, they will get deep industry knowledge that can be taken and scaled both nationally and to the world. Absolutely that is what I am suggesting.

I do not know if that was the implication, but I think that, yes, the government has to work out what it does well, because there is an internal competition going on between the states for resources land where and who is going to be the expert of what. I think the benefit of Queensland is that you have gone down a very methodical path and you have looked at very specific areas that seem to have bubbled up and you are investigating them now. I commend you for that. I think that is exactly on the right track. You have worked out the niche areas. The space industry can be a whole bunch of things, from Mars landers to whatever, and we seem to be focusing on two or three areas, which I think is right.

CHAIR: The time allocated for the session has now expired. Thank you once again, Mr Kinne, for coming along and sharing with us your knowledge and answering our questions. We have no questions on notice.

Proceedings suspended from 12.30 pm to 1.04 pm.

CHAIR: The committee's proceedings are proceedings of the Queensland parliament and are subject to the standing rules and orders of the parliament. The proceedings are being recorded by Hansard, and witnesses will be provided with a copy of the transcript. To assist with clarity, can you please identify yourself when you first speak, and speak clearly and at a reasonable pace. All those present today should note it is possible that you may be filmed or photographed during the proceedings, and images may also appear on the parliament's website or social media pages. The media rules endorsed by the committee are available from committee staff if needed. I ask everyone present to turn off mobile phones or put them onto silent. I also ask that if witnesses take a question on notice today they provide the information to the committee by 10 am next Friday, 23 November.

BLAKE, Mr Duncan, Space Law and Strategy Consultant, International Aerospace Law & Policy Group

WHEELER, Mr Joseph, Principal and Legal Practice Director, International Aerospace Law & Policy Group

CHAIR: I now welcome Mr Duncan Blake and Mr Joseph Wheeler from the International Aerospace Law & Policy Group. I invite you to make an opening statement, after which committee members may have questions for you.

Mr Wheeler: I am sincerely grateful for the opportunity to speak with you in person and make submissions to the committee's inquiry into job opportunities in Queensland arising from the establishment of the Australian space industry. I commend the committee for its inquiry into this very important subject. I would like to start by summarising the relevant background, knowledge and experience of IALPG for two reasons—for the purposes of transparency and so that you can make your own assessment of the strength and authority of our evidence here today.

IALPG, otherwise known as Australia's air and space lawyers, was founded by me in 2015. I am an alumnus of the McGill University Institute of Air & Space Law in Montreal, and my practice is in the field of law predominantly for aviators and those who derive their ability to travel or their incomes from the air—that is, pilots, remote pilots, the industry and air passengers. I consult as aviation legal counsel to the Australian Federation of Air Pilots, which is the largest professional association of airline pilots in the country by membership number. I consult to firms globally and in Australia on air accident compensation claims cases and through the Australian Airline Pilots' Association, or AusALPA. I am vice-chair of the legal committee of the International Federation of Air Line Pilots' Association, or IFALPA, which represents over 100,000 international pilot members and their professional interests globally. I am also a member of the professional government affairs committee of IFALPA, and I am appointed to the management committee of the Australian Certified UAV Operators Association, the largest commercial drone operators association in Australia. I am also a semiregular commentator on aerolegal and aeropolitical affairs for various media outlets.

I am joined today by Duncan Blake, who is special counsel with IALPG. Duncan served for 22 years in the Royal Australian Airforce as a legal officer in postings at the tactical, operational and strategic levels in Australia and was deployed abroad before transferring to the reserves in January 2017. Duncan speaks regularly at international events such as the United Nations and the Pentagon on the law of outer space, especially in a military and strategic context. Duncan has initiated and chaired interdepartmental and international working groups on space law in a strategic context and has been, and is, the predominant adviser to Defence on space law matters for over a decade. Duncan has also supported Defence space capability more broadly, not just in a legal context, including a posting in which he managed the development of a concept for the future military use of space, encompassing the essential relationship between the Defence space industry and the civil space industry.

In addition to his position as special counsel with IALPG, Duncan is managing editor for the Woomera Manual Project, an international research project initiated by his masters thesis at McGill University, in which experts in space law and the laws of war from across the globe objectively articulate and clarify existing international law applicable to military space operations. His experience spans legal support to military operations in all domains: land, sea, cyber, electronic and particularly air as well as space. Duncan is chair of the Australia New Zealand Space Law Interest Group plus a member of the Advisory Council of the Space Industry Association of Australia as well as many other military and legal affiliations. While Duncan is centrally involved in the Defence space industry, he is still well connected throughout the civil space industry and his participation and contribution is highly sought after within that industry.

We are Australia's air and space law firm and we bring together expertise in international aviation, space, drone, military and government law to provide constructive legal and policy advice and solutions to aerospace business problems. We are proud to provide services to a variety of Australian and international law firms in addition to private clients through advocacy on aviation and space regulatory matters, international representation as well as aviation compensation claims, advice and representation.

In spite of our many affiliations we are speaking today only for IALPG. In addition to our professional interests, Duncan and I and the staff at IALPG are passionate about space and facilitating a strong Australian space community. We are committed to all of the submissions that we have previously made in writing and which you have read and which we will further expand on today.

Mr Blake: We submit that there are two related key words that could form the core themes of the Queensland approach to its part in the global space industry and would provide the best possible direction and guidance to promote jobs and industry in Queensland. Those words are 'supplementary' and 'complementary'. I will explain the application of those two words in very summary terms and then I will expand on them.

Firstly, Australia does not need to replicate the space infrastructure of our friends, allies and partners around the world; we can supplement the existing infrastructure. Secondly, the surest path to global success for Australia is by synergistic cooperation within the entire Australian space community. That is, the activities of all entities in the Australian space community should complement one another wherever possible.

Returning to the idea of supplementing existing space infrastructure, Australia has long relied on its relatively privileged access to the space infrastructure of its allies, especially the United States. That is as true in respect of civil space as it is in respect of military space, but there is a sovereign margin—a margin of Australian-specific needs—that is not met by access to the space infrastructure of allies. That margin is increasing. It is not increasing because of any growing differences with allies and partners but because space technology is changing and highlighting opportunities for us to do more for ourselves, especially as satellites and launch vehicles become smaller, cheaper and more capable. That would be true, for example, of the advantages that Queensland agriculture and natural resources industries could get from more frequent space based remote sensing, precise positioning and communications, especially with internet connected devices.

This is not just about Australia, though. The opportunities are far broader than Australia. This increasing margin for Australia is common to any country in the position of relying on the space infrastructure of others, of which there are many. Even within major spacefaring states it is common to the commercial sectors with a growing appetite for space derived services. That is, satellites deployed to address Australia's increasing sovereign margin can also be used to satisfy growing demands everywhere.

In the military context, Australia's growing sovereign margin is apparent even in open-source material. Again I emphasise that this is not about differences with allies, but acknowledging the expected demands, pressures and vulnerabilities of the infrastructure that our allies control in a range of contingencies as well as recognising that smaller, cheaper, more capable and more agile satellites and launch vehicles offer the possibility of greater redundancy and resilience as well as space missions that are more specifically adapted to the needs of a particular military campaign.

It is actually in the interests of allies like the United States that we should develop what are known as Operationally Responsive Space capabilities of our own to launch small satellites responsively to operational demands—that is, to meet the needs of operational commanders in a specific military campaign. These would supplement the existing infrastructure of a small number of big, highly capable, long-duration satellites serving strategic needs. Having a network of Operationally Responsive Space capabilities among Five Eyes allies would be a very valuable thing. That is why I have elsewhere advocated for the Australian Defence Force to develop this capability by committing to launch every two years, in conjunction with Exercise Talisman Sabre out of the Shoalwater Bay Training Area, at least one satellite in conjunction with our allies and to iteratively expand our part in those launches until we can do every part of it ourselves. The military space need and civil space need I have just described coincide nicely with the proposal by Gilmour Space Technologies and others to develop on-demand small-satellite launches as an Australian niche.

I return now to the theme of complementarity. As you are no doubt aware, there has been competition amongst the states and territories about the siting of the Australian Space Agency. In our view, shared by many, there is much more to be gained through various entities in the Australian space community complementing the capabilities and natural advantages that each has, and that is certainly true of Queensland. We focused on launch deliberately, because as you would know there

is a concentration of launch related enterprises in Queensland; namely, Gilmour Space Technologies, Hypersonix, Black Sky Aerospace, Heliaq Advanced Engineering, the University of Queensland, the University of Southern Queensland, Teakle Composites and the Moody Space Centre. Queensland has Australia's only commercial suborbital launch site, which is about to be used in a couple of days. You may have heard about that. With Queensland's wide open spaces and long eastern coast, it is well situated for launches of all types.

Queensland also has a long heritage and strength in the aviation industry. The experience in respect of air traffic management, such as in the Brisbane centre which provides air traffic services for a huge portion of the earth's surface, would be valuable in respect of the development of an increasingly critical space traffic management regime.

Other states and territories have other capabilities and advantages. The Australian space industry as part of the Australian space community is now characterised by a lot of enterprises in relatively niche areas. Global needs for space derived services cannot be met by niche enterprises and disparate states and territories competing with one another to offer only a small portion of the space solution to global civil and commercial problems. If we can act collectively, complementing one another to offer more comprehensive solutions, we have a better chance of winning global market share.

We submit that Queensland's part in those comprehensive solutions could be developed iteratively, starting with a test site for the development of launch technologies and progressing quickly to the establishment of an orbital launch facility at the same site or elsewhere, building on experience from the test site. Such a test site could concurrently host the sorts of space enterprises that need to be hands-on with equipment in order to develop their technology. This would be a complement to other incubators and innovation hubs, typically in or close to the CBD of Australian cities, that suit the needs of enterprises in service industries, including space derived services, that do not need to be so hands-on.

While we advocate that Queensland and all of the Australian space communities should take a complementary approach, there is a need for overall coordination and leadership. Predominantly, this falls to the Australian Space Agency. However, we would like to suggest a way in which Queensland could take a proactive and leading step. It relates to a suggestion by Gilmour Space Technologies.

Gilmour Space Technologies has suggested that collectively the Australian space community could commit and contribute to an Australian signature space mission—something that would not just galvanise people such as Joe and me but also inspire the entire Australian population. They have suggested three possible missions, each involving reaching beyond earth orbit to the moon, to Phobos or to a near-earth object. All of those would help to develop technology for off-earth mining, something to which the natural resources industry in Queensland could make a significant global contribution.

In its response to the review of Australia's space industry capability, the federal government supported in principle the idea of dedicated funding every three to four years for major national space projects to meet national and international needs and to participate in discovery science missions as part of international consortia and national space competition missions. There is an excellent precedent for a way in which the Queensland government, in conjunction with industry and perhaps in collaboration with other states and territories, could have a very strong influence on the decision of the federal government to fund such a project.

The Ansari X Prize, the Google Lunar XPRIZE, America's Space Prize and others are examples of national and international space competitions that have had great success in generating industry capability and sales well in excess of the value of the prizes themselves, even if competitors did not ultimately succeed to claim the prize. Queensland and others could set a challenge for the Australian space industry—a challenge of Queensland's choosing. This could in turn be complemented by federal government funding, as foreshadowed in the federal government's response to the review of Australia's space industry capability. There is precedent in Australia, too. Almost 100 years ago, one-time Queenslander prime minister Billy Hughes initiated the Great Air Race to Australia for a prize of £10,000.

At IALPG we have previously advocated for Space Prize Australia and will continue to do so, because this could inspire the entire Australian population, energise the Australian space industry and attract a lot of positive attention, innovation, energy and investment to Queensland. Space Prize Australia is one of several examples of how IALPG has sought innovative approaches to facilitating and supporting the Australian space community.

Another example is a grant application by IALPG in conjunction with the University of Adelaide to develop a web based tool to help Australian space industry participants navigate the basics or 101 of the many areas of laws applicable to their space activities in Australia and abroad. If the application is successful, we anticipate that this will be known as the Australian Navigational Guide Explaining Laws for Space, or more simply by the acronym ANGELS. We hope to announce the success of the application very soon.

More generally, we facilitate collaboration, especially at the intersection of aviation law and space law, whether in a military or civil context, and drawing on our networks with regulators, industry and others. The Australian government has rightly committed itself to the safety of air passenger transport services as the first priority in airspace administration, and that is unlikely to change. We are committed to helping the Australian space industry to advance in sophistication and frequency of operation in ways that do not undermine that priority.

Whatever we do—and we know that it can be done safely if the aviation and space industries work together as they do in other nations—we must remember that airspace and space are shared resources that can be exploited safely through proper policy development and consultative effort. Although IALPG works internationally and draws on consultants across the globe, it is based here in Brisbane, and as the Australian space industry expands so will the associated legal work and this, too, will attract jobs and commerce to Queensland.

Mr Wheeler: Finally, again we would like to thank the committee and you personally for the opportunity to speak with you and to make these submissions. We are passionate about the Australian space community. We are deeply involved with it and inspired by it. I hope you can see by the nature of our submissions that we are keen to contribute to the success of the Australian space community here in Queensland. We welcome your questions.

CHAIR: Thank you very much, indeed. It is a great idea that every two years the ADF launches a satellite in conjunction with Talisman Sabre. Bearing in mind that we are in the public arena, could you tell us some of the advantages for the military in having such a satellite as well as the advantages for Queensland?

Mr Blake: Five Eyes' militaries have spoken about and expressed some concern about the vulnerability of space infrastructure generally. One of the reasons for the vulnerability is that the space infrastructure up to now—although it is changing—has been characterised by a relatively small number of large and highly capable satellites that represent juicy targets, potentially. They could in theory be disrupted in quite a number of different ways. One of the responses to that is to be more resilient and redundant, so to have more redundancy available and more satellites available to spread it through a larger number of small satellites and to have the capacity to replenish what is on orbit. That is where Operationally Responsive Space comes into it. In part, it is the capacity to replenish things.

One of the things that we as lawyers are naturally very interested in is that the Australian government has committed to a rules based order for space. That is important, because we do not have a lot of space infrastructure ourselves. We rely on the space infrastructure of others, so it is very important that others play nicely in outer space in order that we can continue to access the space infrastructure. Nevertheless, there are those vulnerabilities and those potential threats. It makes sense to think about how we fortify ourselves against that or how we protect space infrastructure, although I do not want to overly dramatise things.

The other issue is that the space infrastructure that the military uses is not just about fighting wars. That is not the only thing the military does. The spectrum of operations ranges from humanitarian aid and disaster relief, including United Nations missions, to wars involving national self-defence. In all of those operations, space infrastructure is crucial. In all of those operations, operational commanders—not the strategic level commanders but the operational commanders responsible for delivering results in a particular campaign—typically find that they do not have enough access to space infrastructure. With big satellites, it tends to be held back for strategic reasons and the operational commanders have to compete for priority for access to those sorts of things.

If Queensland could participate in developing operationally responsive space, that would be valuable to the Australian Defence Force, in my view. I think our allies in the Five Eyes countries would regard it as very valuable as well.

CHAIR: One of the key things for any innovative and emerging industry is protecting its intellectual property. These start-ups and new companies are creating incredible new technologies and ideas, but are they failing to protect their intellectual property?

Mr Blake: We have spoken to quite a number of start-ups. In other capacities I have interacted with start-ups. Intellectual property is a big concern. It is not something that all start-ups know a lot about. With all due respect to the start-ups, they are rocket scientists by nature. They are very clever. They tend to look up things, but not always get it right when they look things up. They do need some help with intellectual property, especially in respect of commercialisation, because small start-ups are going to partner with others that want their piece of the intellectual property 'pie'. There is always a question of how to divide up the intellectual property between the brand-new start-up and whoever is assisting or funding them in some way.

Mr Wheeler: Generally, there is a dearth of professional services accessibility for start-ups, definitely in the aerospace sector. It is something that is generally provided by innovation hubs, accelerators and those sorts of programs, but not everyone is involved with those. It is something that we have seen requires some strength of support.

Mr BATT: Mr Blake, the Talisman Sabre caught my attention. It sounds like a great idea. Is your plan that only Defence would use that site? Would it be open to other businesses to launch their satellites as well and could that work, being on Defence land?

Mr Blake: The Australian Defence Force and Australia is not big enough as an economy and as a defence force to have its own independent military space program. I cannot speak for Defence, but I have a pretty good idea of the capabilities that are available there. It would make no sense for it to be only a military thing.

Mr BATT: Being on Defence land, it would not be an issue in terms of other businesses coming and using it as a launch site or as a business launch site?

Mr Blake: Absolutely. I think the precedent is already there in respect of dual-use airstrips, for example. There are a lots of dual-use airstrips. Townsville is an example. They are all over the place. I think Amberley is used quite often by civil aviation.

Mr MADDEN: It was. It was used by Qantas for training pilots, but that has ceased now. I should not be answering questions. On the site there are a number of private businesses, including TAE Aerospace and Boeing, that occupy a private site as part of the base.

CHAIR: I make mention that Amberley is in Mr Madden's area. I know he is a big fan of what happens out at Amberley.

Mr Blake: I have been posted to Amberley previously and seen exactly what you have been talking about. I have seen Boeing 747s do touch-and-goes at RAAF base Amberley.

Ms PUGH: I have read your submission. It is very clear. I actually do not have that many questions. I am interested in the Australian Space Agency. You talk about the need in the future for there to be some kind of regulatory body for space activities. In my mind I am envisaging something like a United Nations for space. Would that be a fair description? Could you expand on how you see that operating and what kind of role Queensland and Australia could play in that? I suppose we cannot be too parochial.

Mr Blake: There is already the United Nations Office for Outer Space Affairs. It is a fairly small office. There is also the United Nations Committee on the Peaceful Uses of Outer Space. Relative to other international bodies—for example, the International Civil Aviation Organisation or the International Telecommunication Union—COPUOS, as it is known, is not nearly as prolific in developing regulatory regimes and does not have any formal powers. There is a growing need for some sort of body for better global governance of space. There is a big question in the international discourse at the moment about how that will come about. However it comes about, Australia needs to have an influence in respect of that.

I mention space traffic management. If you think ahead about the number of small satellites going up into space, the degree to which space is already somewhat congested and the possibilities of the future, like asteroid mining, it is quite easy to foresee that there will be a growing demand, almost a clamour, for some sort of regulation of traffic management in outer space. We have already had incidences of space objects, defunct satellites, anti-satellite missiles and other things colliding with one another. We need to establish rules.

In my view, it is inevitable that some international body will come into being. When that international body comes into being, that is going to be a very powerful global body and a very commercially valuable body. I do not think Australia can provide the entire space traffic management solution, but we should try to provide a significant part of it. That would be a very valuable thing for Australia to be part of.

Mr MADDEN: I am very interested in the idea of lawyers being involved in space. I am a lawyer myself. I guess there are two ways I envisage lawyers being involved in this area. One would be with regard to the contractual relationships and understanding the various levels of law, which must be incredibly complex between different nations. I am also interested in the issue of liability with regard to bits of machinery falling on the earth. In terms of the last aspect, is that an issue in Australia or has that been an issue in the past?

Mr Blake: Yes, it is an issue. It is dealt with via the Space Activities Act 1998, which, as you may know, is on the cusp on being renewed. It will become the Space (Launches and Returns) Act 2018. There are a lot of questions that remain unanswered by that legislation. For example, it refers to Maximum Probable Loss and trying to understand what the maximum probable loss would be out of some catastrophic event on launch, for example, would be difficult.

There do not appear to be any good figures globally to encompass all of the potential losses that would occur. The US publishes figures that are standard for a particular launch vehicle and a particular launch site. Their figures on Maximum Probable Loss cover US government property and third-party property. What is not covered is economic loss, environmental loss, property of others—for example, the property of other satellites being launched on the same rocket—and death and injury, although launch safety procedures tend to eliminate that risk altogether.

The Space Activities Act gives effect to international treaties that set up a liability regime and protect the Commonwealth by requiring that anyone wanting to launch gets insurance. The minister can give an exemption if the minister makes a decision that insurance is not required in the circumstances—for example, for small satellites where the risks are quite minimal.

The risk of liability remains. It also very much depends on the nature of the contract, as you mentioned before, between someone seeking to put a satellite in orbit and the launch provider. There can be a number of different intermediaries between those two people. A quite typical intermediary is an aggregator or integrator—someone like Spaceflight or NanoRacks.

Spaceflight is arranging for 64 satellites to be launched from the one rocket. That represents 17 different countries and lots of different contracts. They have standard launch services agreements with their customers. Those launch services agreements typically cover a lot of cross-waivers, limitations of liabilities and requirements of insurance. There is further protection there. It is not a well-traversed area at all.

Mr MADDEN: You have clarified that for me.

CHAIR: It sounds like a lot of work for lawyers to do in this space.

Mr MADDEN: Don't start! The world needs more lawyers.

CHAIR: It does. One of the things that we have heard and that we have stressed since day one of this inquiry is the need for cooperation and not competition. One of the biggest requirements for an industry here is to cooperate with all players and all partners. That is one of the things that you have stressed very well today and in your submission. Can you expand on the benefits of cooperation at any level? How can cooperation help us establish opportunities in Queensland?

Mr Blake: I might start with the individual enterprises themselves. There are anywhere between 30 and 80 new start-ups in the space industry, depending on how you characterise a start-up. Those start-ups are typically quite small. The largest is probably about 50 people. UNSW Canberra Space now has a commercial spin-off called Skykraft. There are others which are relatively large, like Fleet Space Technologies in Adelaide. A lot of others are two or three people.

They have developed expertise and are developing technology in relatively niche areas. They can provide very niche solutions to problems that others have globally, but what they cannot provide is comprehensive solutions, unless they collaborate. For example, UNSW Canberra has done a lot to manufacture satellites and learn how to operate satellites. You have Fleet Space Technologies and Myriota, which have done a bit of that but are mostly about servicing the demand for internet connected devices—the internet of things. Those are complementary sorts of things. Then you have Gilmour Space Technologies, which is developing a launch vehicle, and Equatorial Launch Australia, which is developing a launch facility in the Northern Territory. Black Sky Aerospace, whom I believe you have heard from very recently, is developing rocketry componentry and whole rockets as well, but potentially in a different class from Gilmour Space Technologies.

All of those are relatively complementary. There are different advantages that different states and territories have. Policy development is, in all likelihood, going to happen in Canberra because it is a federal matter. With a concentration of launch capabilities here in Queensland, it is natural that

launch related issues would be considered here more than any other state or territory. South Australia has two companies—two very well funded companies—now, Fleet Space Technologies and Myriota, focusing on internet connected devices. There is a lot of scope for complementarity.

Mr BATT: You mentioned the space prize and you said that it would be a good idea for Queensland to put something out like that.

Mr Blake: Yes. I do not know whether it would be something best done by Queensland and Queensland only. The analogies to which I made reference—the Google Lunar XPRIZE, the Ansari X Prize and America's Space Prize—were largely funded by the commercial sector. There is the possibility of a public-private partnership perhaps. I think a farsighted enterprise out there could see a lot of advantages to putting money into offering a prize.

As I said, the success of these competitions has been not necessarily in the fact that somebody has made it all the way to claim the prize, but in a number of enterprises seeking to get there they have developed a lot of industry capability along the way and they have developed a lot of sales. Even if a company has not made it all the way to claim the prize, it has generated a lot of capability.

Mr BATT: Hopefully with a lot less risk than the one Billy Hughes put out 100 years ago.

Mr Blake: Yes.

CHAIR: There being no further questions, we will now close this session. We do not have any questions on notice. We appreciate that you have come from Canberra. What we are commencing here is a very serious effort to make sure we do not miss out on anything. We appreciate you coming all this way to talk to us today. Thank you very much indeed.

KEAY, Dr Sue, Chief Operating Officer, Australian Centre for Robotic Vision

MILFORD, Professor Michael, School of Electrical Engineering and Computer Science, Queensland University of Technology

CHAIR: I now welcome Dr Susan Keay and Professor Michael Milford from the Queensland University of Technology. I know you have not come from as far as Canberra today. For the record, could you please state your name and the official capacity in which you appear today.

Dr Keay: I am the Chief Operating Officer for the Australian Centre for Robotic Vision,

Prof. Milford: I am a professor of robotics at QUT and also Chief Investigator at the Australian Centre for Robotic Vision.

Ms PUGH: I just had that moment of where I know you from. Michael gave my son a book. He was the guest speaker at our recent Corinda speech night.

CHAIR: We appreciate your links to the Queensland education system. The proceedings of the committee are proceedings of the Queensland parliament and are subject to the standing rules and orders of parliament. The proceedings are being recorded by Hansard and you will be provided with a copy of the transcript. To assist with clarity, please speak clearly and at a reasonable pace. It is possible that you may be filmed or photographed during proceedings and images may appear on the parliament's website or social media pages. The media rules endorsed by the committee are available from the committee staff if required. If there are any questions on notice that we have of you, if you can, please provide answers by 10 am on Friday, 23 November. I invite each of you to make an opening statement after which we will have some questions from the committee.

Prof. Milford: Thank you very much for the opportunity to talk today. What I would like to do is very briefly give my personal perspective on space and the profound influence it has had on me and then present some observations on space in Australia from my perspective of being a professor who also trained in the space industry—I trained in a space degree—and then pass on to Sue.

I am Brisbane born and bred. I have a young family. I have kids with pictures and posters of rockets all over their walls. As I give my personal testimony, you could think of me not as an individual but as a case study of what a young person who is interested in space might encounter in terms of opportunities and challenges in the Queensland landscape.

I was brought up in a family profoundly influenced by and active in the space scene. My father was a physicist in the States during the space race. He worked at companies including Grumman Aerospace. One of my older brothers has spent decades in the space industry—firstly at Hughes Aerospace, then at Boeing Space and Intelligence Systems. Now he is a senior director of system engineering at Virgin Orbit. They are just about to start launching rockets off the underside of a 747 off the California coast, I think, which is just mind-blowing and also incredibly inspirational. I was brought up in the mythology and the inspiration of the space race in the industry, as many young people still are, which is incredible.

I chose a mechanical and space engineering degree at the University of Queensland. Space was the aspirational component of that degree; mechanical was the backup solid job foundation to that degree. I was introduced to things like shock tunnels, the hypersonics program at the University of Queensland and the amazing things that we have done on the world stage in space in Brisbane. I also fell in love with AI and robotics. They are the two loves of my technical life.

In 2002, when I was making decisions about what I would do next—I think it is quite illustrative to think about the options. Both robotics and space options in Australia for an aspiring, young, ambitious person were almost non-existent. This is the challenge that I think faced many other people, including my older brother, in choosing where to make their career and where to have their impact. I am still very passionate and interested in the space race, especially in the combination of space and robotics. I, like a surprising number of my colleagues who are still in Australia, have dabbled and done research in robotics in collaboration with space partners—for example, with NASA's Jet Propulsion Laboratory—and many of my colleagues in Australia have done this.

If you fast-forward to 2018, there is a marked difference right now as a snapshot in the opportunities available for people going into space versus people going into AI or robotics in Australia. AI and robotics have had 10 years of pretty much unbounded growth and opportunity and resources and excitement. Now it is one of the hot topics in Australia. If you take a snapshot of the perception of opportunities in space from a young person's perspective—and I have spent a lot of time talking to young people—it does not have the same widespread impact and awareness right now. It is starting to. I was at a keynote for SpaceX in 2012 in Sydney. For the first time in many, many years I felt a

pang of regret that I had not stuck with space. Then, when I was on a train earlier this year watching the SpaceX launch, I actually had a tear in my eye and I felt another bigger pang of regret that I had not stuck more in the space industry.

I am sure you have had these observations before, but, as someone who does an extensive amount of science communication and outreach all around Australia, I will share my observations. Space is one of the very few topics that can universally captivate, motivate and mobilise an entire population. It is an aspirational challenge. It is not a problem that we are facing and trying to solve; it is an aspirational goal, which is different. It is no accident that we see that space communicators and astrophysics communicators around the world, and especially in Australia, are the most successful science communicators in the landscape because of the topic. It has so many of those advantages. It has those fundamental questions such as 'Are we alone?' and so forth.

In terms of growing our capacity, our jobs and our resources in the space industry in Australia, we can do that by replicating the best bits of what we have done in other areas which have succeeded such as in robotics—and Sue will talk about that, I am sure, in more detail—but there are barriers. It is very easy to do an app or a new software play in AI. It is not so easy to develop a new launch system, as I am sure your illustrious guests today have testified.

One of the other challenges is that areas like robotics and AI, which we know so well, are a key component of almost every sector of society in terms of government, in terms of corporates, in terms of start-ups. It is almost universally integrated into people's strategic plans. Space is not necessarily ever going to be that way and it is definitely not currently that way. It does have one key advantage—and it is notable that one of the leading robotics groups in Australia had as its aspirational example the space race in the sixties, not a robotics challenge. I think that is quite telling. I know that is quite ubiquitous around the world—that groups that have no direct role in space have it as an aspirational challenge.

Space is also a field where we have an incredible struggle to retain, train and attract the top talent to Australia so that Australia can stay competitive on the world stage. Space is a field where there is much potential to compete and to stake a hold there. It is very tough in areas like computer science. I think there are as-yet unexplored opportunities in doing the same in space in terms of talent, which is a topic very close to my heart. I understand that there is a strong emphasis for the commercial plays in this area to be based on sound commercial value in the short and medium term, but I think we must pair that with those aspirational blue- or black-sky, depending on how you want to put it, plays—those moon shots, going to the moon, going to Mars and beyond. Those are the things that will really captivate and inspire the population. Thank you very much again for allowing me to testify. I look forward to answering any questions you have.

Dr Keay: I think job creation opportunities that could come from the development of a space industry in Australia are hugely important to robotics. If there is one message I would like you to take away, it is that there really is a strong link between space and robotics. Australia has unique advantages in robotics but also in some other areas, such as remote asset management in the resources sector, that can all be leveraged towards developing an opportunity within space.

The reason this is important—to give you some background about the centre, we are funded by the Australian Research Council. We were created in 2014. We have a life of seven years. Over that time, as part of our mandate, we will graduate more than 80 PhD students. We are headquartered here at QUT, but we are a national centre. We are funded under the ARC Centres of Excellence program, which is the largest national investment in non-medical research that is made in Australia.

Every three years or so the ARC chooses maybe up to 10 centres of excellence. It is unusual for them to be in the technology field, so we are quite unique in that respect. The ARC is looking for areas where Australia can have a niche advantage. For us, our value proposition to Australia was that we are combining computer vision with robotics. Those two things might not sound like they are very different, but they have evolved quite separately. It has only been recently that robots have had the computer processing power to take advantage of all the remarkable advances in computer vision. Essentially, that is for robots to be able to use imagery that you can get from cameras.

Why is that important? That is important because we are still, here in 2018, the largest collection of people with this expertise in the world. We have a niche advantage in this area right now. We are developing talent and technologies that are unique. Our concern then is: what are the opportunities for the talent and the technologies that we are currently developing? This is where space is key. When we were looking at what the opportunities are for the people that we are going to be graduating very shortly, it caused us to take a scan across what the robotics industry in Australia was like. You will get the opportunity to have a look at our centre a bit later.

I also draw your attention to the Robotics Roadmap for Australia that we released earlier this year. We commenced this process through 2017. The reason to do that was that it was difficult to identify our stakeholders. Who is in the robotics industry in Australia? How many people do they employ? What value is it to the Australian and Queensland economies to have robotics in this country? We went about trying to find the answer to those questions, and this is our first attempt. What we found was that we believe that there are more than 1,100 companies that you could classify as robotic companies in Australia and that we believe that they employ more than 50,000 people and are conservatively worth—I have lost the figure—I think it is about $12 billion in revenue to the Australian economy. That is the first time that anyone has tried to put numbers on it. Why that is important—and I think this goes to some of the evidence that you have previously heard—is that it is very difficult to get investment in a sector if you cannot even really define what that sector is. The Australian Bureau of Statistics does not include this sort of information. Robotics can be applied across all sectors of the Australian economy.

When we were putting this together and we were pulling in different stakeholders from the robotics community to develop this roadmap, what became clear was that, although at that time the Space Agency in Australia had not even been announced, people felt that space was integral to the roadmap and that we needed to consider how we could apply the robotic technologies that we were developing to the space industry, regardless of whether Australia had a space agency. The reason people believe that is important is that, if you have a look at the example of a country like Canada, space has had a huge impact on the development of the robotics industry.

Canada is a very similar country to Australia in many respects. It has a population of, I think, 34 million. It is not that much bigger than us. Very much like us, it has a low population density, so a lot of the challenges we have in terms of remote service delivery equally apply in Canada. They invested in space back in the 1970s and developed an industry consortium that created a robotic technology called the Canadarm. It is essentially a robotic arm that is used on the International Space Station to be able to transport goods in and out of the space station. That required such a national effort to be able to develop this technology and then to see it actually in use in space—and I will have to show you are a picture of this—that it now appears on the $5 bill for Canada. That is the sort of country I would like to live in: where a technology that is developed in the country actually features on some of the currency.

I guess that is the level of inspiration that the development of those technologies can create. For us, that is the sort of spark that we would like to see to help join together Australia's currently very fragmented robotics industry and to see some national efforts where we can harness a lot of our unique advantages in terms of the talent that we have in robotics along with our talent in resources and things like remote asset management.

The other thing that came out as a by-product of this process was the discovery that Brisbane is, in some respects, the robotics capital of Australia. For a number of reasons we have ended up delivering a cluster of activity, both here at QUT and also at CSIRO Data 61's facility at QCAT at Pullenvale which means that we have the largest number of robotics researchers in any one given space in Australia. We have these unique advantages. We think there are a lot of opportunities in space for robotics and we would like to see that those are followed through. As Michael has indicated, unfortunately what we find is that a lot of our graduates are very talented people but they do not always see the opportunities that are here in Australia.

CHAIR: Thank you very much for that. Professor Milford, I know that Queensland has produced an incredible number of graduates in this space. For example, you mentioned 80 PhDs in your area. At UQ they had 130 and you are one of those 130, I would say. Is it fair to say that we need to create opportunities to give them the opportunity to come home?

Prof. Milford: I think there are a few different facets to that. These are young, ambitious, idealistic people and they are going to go overseas always but we would like a significant fraction of them to come back, which they have not.

CHAIR: We want them to come back once they start having families. We want to ensure this is where they want to come to.

Prof. Milford: Yes, and some of them will come back if we create the right opportunities. In a way the bigger problem is not those few superstars but it is that pack of highly motivated graduates, both undergraduates and PhDs, who get out and look around for opportunities. They are not just looking for money. A small number of people are motivated very much by monetary opportunities overseas, but most of them want to have an impact, they want to do something interesting and they want to feel like they will have some chance of changing the world, of leaving some sort of stamp that

leaves it in a better place. Their perception, as we have noted, at the moment—and given their short time frame; these people are impatient—is that that place is generally overseas. If you are an old academic like me with a young family, you will have the patience to hang around and try to see things through, but youth understandably do not have that patience.

Dr Keay: And we do not have any iconic robotics companies in Australia yet. That is not to say that we do not have Australian robotics companies; we clearly do. However, none come to mind that might come to mind when you think of other countries in terms of robotics companies that our graduates would aspire to work with.

My sister is the managing director of Silicon Valley Robotics so she sees things from the other side of the ocean. In Australia we have a terrible record of venture capital investment in new robotics start-ups. Michael previewed this. It is more difficult trying to raise money for hardware start-ups, which essentially are what robotics start-ups are. We have raised less than $9 million. In terms of the publicly available data on investment, over the last 15 years Australia has invested less than $9 million in robotics start-ups.

My sister sees this from the other side, where in Silicon Valley she sees a lot of young Australian companies not even try to find investment in Australia. They will go straight to the States. One thing she finds frustrating, and it might not be something you can solve, is that once Australian companies make that decision to go overseas and to accept investment from a country like the United States it is like they become dead to us. There is no opportunity for them to come back.

We have the Hot DesQ program here, but that does not help if you have already set up a company in the States, even if you are full of Australians. There is no entry point for you to come back and set up operations easily in Australia because you are considered to be American. As well as trying to foster opportunities for homegrown robotics companies, it would be interesting to explore whether some of the ones that have sought investment overseas can be encouraged to maintain their connections back here and to develop things here.

CHAIR: The Hot DesQ program is part of the Advance Queensland suite of packages. I would think that over the last couple of years since we got that up and running that has offered new opportunities for your sector as well. Would that be correct?

Prof. Milford: Full disclosure: I am the recipient of several grants from the Queensland government, one through the Advance Queensland scheme. That has been fantastic for supporting robotics research with multinationals that have a significant presence here to hopefully create some jobs and opportunity here. That has not enabled me to attract anyone who would not have stuck around anyway, partly because it is risk averse, understandably.

The appeal to me of space, unlike mining and agriculture, which, rightly or wrongly, do not have the most glamorous appeal to many people, is that space has it all. Space has the heavy industrial component to it but it also has that amazing appeal which a lot of other industries do not have, and space has not lost that veneer in almost a decade of people actively thinking about it.

Dr Keay: I might be wrong, but I cannot think of a single example of the Hot DesQ program bringing a robotics company back here.

CHAIR: That may be something that we can look at as well. Hot DesQ is good in certain areas such as bringing personnel back, but there may be more work that needs to be done to bring across a large, capital intensive company. Would I be correct in that?

Dr Keay: Yes.

CHAIR: It looks as if Queensland is still going to be producing a large number of graduates within robotics and various aspects of the space economy; is that correct? We are going to still keep pushing them out there?

Prof. Milford: In areas like mechatronics, which is mechanical plus electrical, the numbers have doubled and doubled. That has grown quite rapidly over the last five to 10 years. It is very easy to make the case because this is the stuff that is always in the news—the robots and the AI—so it is very easy to attract people towards that industry. When they come out the other end, we have the retention problems that we have already talked about and the perception of what their opportunities are. I am not up to date on the number of mechanical, space and other space related degrees in Queensland at this stage.

Mr BATT: Dr Keay, you mentioned in your opening statement that Australia has a unique advantage in robotics. Can you explain what that is and why it is?

Dr Keay: We have the largest collection of people who are specialists in what we are calling a new field, robotic vision. There are people in other areas of the world who have that speciality but not as a collective. We have a critical mass of expertise in that area and a short window of opportunity to take advantage of that.

In addition, I think Australia really leads the world in field robotics. That is by nature of the fact that those robotic systems have been developed to account for the Australian environment. Australia is the first country in the world to automate mine sites. Australia is the first country in the world to automate ports. The Port of Brisbane is the first company to use robotic straddle carriers. There are a number of areas where Australia has led the world in the application of robotics and automation and the development of those technologies.

Ms PUGH: I was looking at you before, Professor Milford, and I thought you must have been to one of the earlier hearings. Then it hit me when I looked up again and I saw all of this. You spoke very well at the Corinda graduation about how we can get young people engaged in coding and robotics and therefore get them into space industries, something I am very interested in. I am very lucky that at my local state high school they are doing an exceptional job. I understand from discussions that they are one of the leaders in how to actively engage kids so they are ready to come into programs like yours. With all of the young graduates you are dealing with, is there anything that you think the state education system could be doing differently or better to prepare more young people? Do you think there is scope to take more young people through or are you getting enough high-calibre kids coming through with the skills they need after they finish year 12? Are they meeting your demand?

Dr Keay: I am going to answer that a little tangentially inasmuch as we have a real diversity problem. It is not so much what skills people are coming in with; it is the fact that we cannot get girls to consider going into these areas. At the moment in Australia only 15 per cent of engineering students are female. That has not changed in 10 years. Despite the fact that we are putting in all of these fantastic STEM education programs, we are not seeing an increase in the number of women who are participating.

In terms of what I think the state can do to help address this, I do not know whether you are familiar with the SAGE initiative—Science in Australia Gender Equity—which universities have adopted. Essentially, it is about publication of some simple numbers. Schools would already have data on the gender ratios in all of their subjects. I believe that should be made public. The reason for that is that I think you would have much more effective information sharing across schools and be able to see which schools are successful in maintaining a high cohort of female students in top level maths and science if we could see those numbers. Then parents could make a decision, if they have the opportunity to, as to where their daughters can access the best opportunities to pursue particularly STEM subjects. Schools that perhaps are not tracking as well can look to their peers and see what they are doing differently. Something has to change because those numbers, as I said, are not changing in terms of how many women we are getting into the area, and in areas like this where there are skills shortages that is a real problem.

Ms PUGH: It is; it is a huge problem. So 15 per cent and stagnant for the last 10 years?

Dr Keay: That is my understanding. I can look those figures up.

Ms PUGH: That is significant. I have made this observation before. When I went to Jindalee State School the numbers of boys and girls doing robotics—they have a robotics program there—was equal. It seems like at a certain point the girls are opting out and I have a feeling it is around that early high school stage, which is where my daughter will shortly be heading.

Dr Keay: There are some powerful societal factors at play as well, but I think some schools are probably doing a better job at retaining girls than others.

Prof. Milford: On that note, there are significant studies that show that differentiation starts happening as early as six. This is not a plug; this is purely for informational purposes. We do early childhood books that combine the space industry and appropriate female role models with a lot of feedback from people who know a lot more about this than I do, because we made many mistakes. We had a pink suit initially and we changed it to a purple suit and many other things, but I definitely see that differentiation quite early on. I am guilty of it with my own daughter and have to keep catching myself up.

In terms of what can be done with young kids in school now, I am much more enamoured with the education system than I was when I left it 20 years ago but there are a few things. First of all, through what we do we find out that young kids are not, in my opinion, getting sufficiently exposed to

the broad concepts of transformational things like AI and robots, even though there is a focus on coding, for example, which is really a method and most people will not end up coding but everyone will be exposed to AI, robotics and automation.

The second thing is the entrepreneurial mindset of young kids. I know that a lot of people are doing a lot about this, but by the time they get to university a lot of the battles have been fought and won or lost around how entrepreneurial they are and how well people can adapt to non-traditional career pathways as well. That is my observation.

Mr MADDEN: I understand that research was done at QUT with regard to the precision application of herbicides and the identification of weeds, particularly prickly acacia. Is it your section that is dealing with that?

Dr Keay: Yes.

Mr MADDEN: Can you give me a feel for what research you are doing and maybe what PhDs are being done in that particular area? I have a particular interest in the control of prickly acacia.

Dr Keay: I do not know how many PhDs are being done on prickly acacia.

Prof. Milford: I can give you an outline of the agricultural robotics program. First of all, there are a number of agricultural robotics projects around Australia. We have two primary platforms. We developed a half-tonne agricultural weeding robot called Agbot II. It uses precision GPS, computer vision, robotic vision and some AI based technologies to identify the bad weeds from the good weeds. It is another good killer robot. They have looked at killing the weeds by hoeing them out of the ground, by microwaving them and by the precision application of pesticides.

I think it is illuminating to note that that project trained several PhDs. One of those graduates is at a self-driving car company in the UK, one of those graduates is at a self-driving car company in the US—Uber—and another one of those is at a different self-driving car company in the UK. I could go on and on, but you get the picture. We do some great work here that is world class, but then it is really hard to capitalise on it and scale it up here.

CHAIR: That last point touches on what you said before about venture capital and the development of this great early work into viable businesses. Specifically, you talked about hardware, that it is hard to get venture capital focusing on hardware—robotics. Could you expand on that? Obviously, software development attracts those funds. Why do you think that would be?

Dr Keay: Because it is less risky and not as capital intensive. If you were to develop a platform like Agbot II that Michael suggested, there is a lot of capital expenditure. You need a large space. If you are supporting a start-up that is a software start-up, you can pretty much just give someone a computer and a desk. We have some support beginning here. Brisbane is the first city in Australia to have some hardware incubators, but they still are not at the same scale as ones overseas. In Boston there is a group called MassRobotics. They have a big warehouse where people can prototype quite large equipment. We have some limited 3D-printing and CNC-machining capabilities but nothing that really would help you develop something on a large commercial scale, if that is the sort of robotic business you are looking at. In particular in Australia, where a lot of our opportunities are in agtech, they are not likely to be toys.

CHAIR: In terms of producing it, you need a warehouse and you need access to capital to build large machines. That includes materials and the expertise to do that.

Prof. Milford: Yes, which is why the limited work that happens in that field in Australia is usually done by large multinational corporates that have the capital and runways to do that. The other factor in all of this is that, when you looking at what people to do in terms of risky initiatives, like a start-up, it is what they would do afterwards. If they fail at a software start-up but they learn the skills of artificial intelligence, they have unlimited options—as long as they are competent at it afterwards. If you fail in a hardware start-up, your options after that are generally more limited. That is not our fault; that is just the nature of the current climate globally.

CHAIR: We have talked about robotics as a niche market. We heard earlier in this inquiry about Canadarm and that the Canadians have carved out a niche in terms of robotics, but I am hearing that that is only one part of it—an arm for space.

Dr Keay: Yes, we have significant opportunities in space exploration, given the fact that we have this expertise in remote asset management and that we have such a strong resources industry. If there is more work on the moon, before you would go up there you would need to have a robot go up there to build the facilities that people will live in. To do that you need to have robots that we are trying to give capabilities to that can see and understand their surroundings and can self-repair. As

many Australian operations now do, you have to be able to do all of this with only remote control available. You cannot send a human to fix things easily. The robots will have to be able to do all of those things.

We would also be looking at using materials that are available there rather than transporting them. That is where our resources expertise would come in—potentially moving towards in-situ mineral processing so that you could make the materials that are required for whatever activity you are thinking. I think at the moment there are some ideas about having a global village on the moon's surface where different countries can contribute. In all of those things you will rely on robotics. I think we have a niche advantage from our experience in the resources sector.

CHAIR: As part of our inquiry we are pointing out where the jobs opportunities and the economic advantages lie in Queensland. We have heard a lot about finding that niche and dominating that niche. It would be a mistake to think that the Canadians are the only ones. That is one niche area of robotics that they have. We have a good basis to exploit other niches within robotics for space.

Dr Keay: I think that field robotics would be the key. Obviously, the Canadians have the robotic arm side of things sewn up.

CHAIR: Are there any other questions?

Ms PUGH: No, I am just really keen to see the facility.

CHAIR: There being no further questions, I will close this session. In terms of questions on notice, could we have a response on the number of women graduates in engineering back by 10 am on Friday, 23 November? We will email you that question. That would be very useful for us as well. That concludes this hearing. On behalf of the committee I would like to thank all of the witnesses who have participated today. It is great that we have had people travel from all over Australia. We appreciate the evidence that everyone has given us. I thank our Hansard reporters. A transcript of these proceedings will be available on our web page soon. I thank our committee secretariat as well. I declare this public hearing closed.

The committee adjourned at 2.22 pm.