



ROYAL AUSTRALIAN AIR FORCE

Podcast Transcript

Conversations on The Runway – Space Series Episode 8 – ‘*Hypersonics and a Vision for Australian Space*’

Host: Michael Veitch

Guests: Prof Russell Boyce

Michael

Welcome to the final in the series of Conversations on the Runway, the space episodes. Perhaps the Lost in Space episodes? No, I have promised my boss I will not draw yet another ludicrously long science fiction bow to the current realities of space, although I haven't mentioned the Thunderbirds. Later in the show, we will be delving into a potential space emergency scenario that may involve the International Rescue Team, but we'll definitely see Australia playing a major part, and it's a story not in fact too far removed from reality as our esteemed guest, Professor Russell Boyce, will illustrate.

Michael

What have we learned over this series of podcasts? Well, space is big, obviously. But so is its potential for advancing mankind both on this rock and potentially others. Hence, we are using space in ways right now utterly unimaginable a few decades ago when we first went up there. Our dependency on space is increasing exponentially and so therefore is its vulnerability, making space, as one general put it, "The ultimate high ground of any future conflict." We are, we learned, already talking about human settlement on the Moon and even Mars. Many stakeholders, nations, corporations, academics, engineers, and educators are taking it very seriously indeed.

Michael

Diversity in space, we learned, means that it is no longer just blokes with crew cuts and names like Chip and Todd sewn onto their spacesuits that will get up there. The industry generally worldwide is continuing to open up for women and other clever people from all sorts of nations and backgrounds. And that surely is a good thing. The lines between government and commercial uses of space are rapidly breaking down. The laws to govern this vacuum, pun intended, could not be written fast enough even if stakeholders could agree on those laws, and even who should be writing them. The UN can, and does, have a great deal to say on regulating space, but is anyone listening?

Michael

More than once I described space as the Wild West of the 21st century and more than once our eminent guests agreed, which I found rather startling. Space is full of junk it seems, and it's only going to get worse. Satellites are, some of them, the size of a loaf of bread, and can be put up there to do more with less money by an increasing array of countries and corporations. Where, however, does Australia stand in all this? We had a whole episode devoted to that too and learned that we did indeed have a space industry, and then we lost it. Can we get it back again?

Michael

On our final episode of this series, the space series of Conversations on the Runway, we talk about some of the most exciting things we are doing in space today and ask, "What for Australia lies ahead?"

Professor Russell Boyce has a good deal to say about an Australian space future. He leads the University of New South Wales Canberra Space Research effort, at which venerable institution he is also Chair for Intelligent Space Systems. Add to this the 25 years ... gosh, he hardly looks old enough. Russell Boyce has worked in the breathtaking arena of hypersonics research, in which he also finds himself Chair at the University of Queensland, Executive Council of the Space Industry Association of Australia, yada-yada-yada, the only Australian fellow of the American Institute for Aeronautics and Astronautics. Honestly, I'm just going to have to put a biro through the rest of Russell's qualifications and achievements as simply listing them will devour our entire show. Russell, welcome to Conversations on the Runway.

Russell Boyce

Thank you, Michael.

Michael

I'm going to be asking big things of you today because I'm hoping you're going to bend my brain a bit as we take apart a particularly tricky international space emergency scenario in which Australia will, you tell me, play a part, albeit imaginary. We're even going to, I guess, sort of war game it a bit or at least Dungeons & Dragons it a bit. But first, the utterly tantalizing fields you are working in, have worked in, building an Australian space future both practically and educationally. Let's start with hypersonics. Just a thumbnail please. Am I thinking, Russell, London to Melbourne in 40 minutes, that sort of thing? Or is my imagination once again running away with me?

Russell Boyce

Michael, that's slightly too fast for hypersonics.

Michael

I hate the long haul plane trips. I was hoping you could cut a bit of time off the trip to London.

Russell Boyce

Well, if you were on the International Space Station, you would do London to Sydney in about 40 minutes. That is about the right time. It takes 45 minutes to do half a lap of the Earth in low Earth orbit. But hypersonics, on the other hand, hypersonics is the art of flying very, very, very fast in the earth's atmosphere. A typical hypersonic future application would be traveling at about eight times the speed of sound. We call that mach 8. At mach 8, how far would you get in 45 minutes? That would be approximately Johannesburg to Perth. It's still cranking along pretty fast.

Michael

"Supersonics on steroids" was one description I read, but whereas in supersonics which has a definite speed ceiling, I believe hypersonics, it's slightly more open. Is that correct?

Russell Boyce

The distinction between supersonic flight and hypersonic flight is quite nebulous. Some people say it's at mach 8. Some people say it's mach 4, mach 5, mach 6. In actual fact, the difference between the two is when it gets really, really hard for the engineer. So, your military listeners, for example, would know well. There are supersonic aircraft in service. That's quite a tractable engineering problem to be able to develop those aircraft. Hypersonics is where the temperatures involved start to melt the aircraft. Materials that are needed, you need to get to very, very exotic high-temperature ceramics or very, very sophisticated layers of different types of materials to be able to handle that. And depending on when the application...

Michael

For insulation purely. In layman's terms, to keep the heat of the friction of the air you're moving through out of the interior of the hypersonic craft.

Russell Boyce

That's right. For example, the hypersonic flight experiments that I've been involved in 5 to 10 years ago, we would do a mach 8 experiment and it would be in the earth's atmosphere. We would have just a few seconds before the aluminum and steel structure of the experiment would literally start to melt and fall apart.

Michael

In what situations were these experiments conducted? Tell me about them.

Russell Boyce

Some of your listeners may remember the HyShot program, which was a program initiated by the University of Queensland. That evolved into what was known as the HIFiRE Flight Experiment program, conducted jointly by Australia's Defence Science and Technology group and the US Air Force's Air Force Research Laboratories, and also participation by the University of Queensland and others. Imagine creating, for example, a scramjet test, putting it onto the top of a two-stage sounding rocket, launching from somewhere like Woomera. Or in the case of the campaign that I led in the SCRAMSPACE program, launching from a rocket range north of the Arctic Circle in Norway. Attempt to get that rocket up into space, not into an orbit, because then it would just keep going around the earth, but up to about 300, 400 kilometres altitude. And as it drops back into the atmosphere, it reaches the speed that you need at just the right altitude you'd need to do that flight experiment. But as I said, you only get a few seconds before it bites the dust.

Michael

Just remind us what SCRAM is. I've heard that term before. Can you give us a thumbnail on that please, Russell?

Russell Boyce

SCRAM is Supersonic Combustion RAM. So a scramjet is...

Michael

I've heard of ramjet. Ramjets have been around since the Second World War. The German flying bombs were ramjets, weren't they? This is a further development from that, probably a very primitive technology?

Russell Boyce

Yes and no. The German technologies were very sophisticated, but they were pulse detonation engines. But certainly, ramjet engines were in service very early on after the Second World War. A scramjet is an air-breathing engine that has no moving parts and the airflow ... in fact the mixture of air and fuel in that engine is supersonic all the way through, from inlet through to exit. That's a very special collection of physics and chemistry that does wonderful things for you in terms of being able to fly at very high speed, but it comes with some very, very peculiar challenges, which mean the world is still working on that technology.

Michael

Let's nod to the military defense heritage of *Conversations on The Runway*, Russell. Is hypersonic primarily a military application or civil, or a blend?

Russell Boyce

There's a number of ways that could be answered, but the most likely future application of hypersonic technologies would be military. The reason I say that is that the most likely way that we will get hypersonics to work is in hypersonic vehicles or craft that stay at a constant speed; they cruise at around about the mach 6 to mach 8 speed. It's not very far to step from that to a missile application.

Michael

Is the Blackbird one of the fastest aircraft, I think, that's still in the world, isn't it? The great American reconnaissance bird? Is that a hypersonic aircraft or a supersonic?

Russell Boyce

It's very high-speed supersonic. I forget the exact speed; I think it was about Mach 3.5.

Michael

That rings a bell too. I was going to say it's about the 3-mach, but it doesn't quite qualify into the hypersonic range.

Russell Boyce

No. Although it was starting to get tough from an engineering perspective, I know that the fuel tanks would leak. When it was sitting on the runway, it needed the aircraft to actually heat up, once it was at full flight speed, for everything to pull together and be nice and tight and sound.

Michael

Are these the sort of engineering conundrums that the team you're working with, are dealing with hypersonic crafts?

Russell Boyce

Well, these days, no. My former team, my former life if you like, in hypersonics, yes, we were very concerned about the heating. We were very concerned about the complexities of getting a scramjet engine to work at all. We were hoping to be able to do that for access to space, to be able to launch satellites into orbit. My conclusion was that's unlikely to be what we will use hypersonics for. It's just simply too hard. And that's probably a conversation for another day. But these days, my team develop satellites and, in particular, intelligent satellites.

Michael

I'd like to talk about another area you've been involved with, Russell. Space Situational Awareness, SSA, the science, from what my modestly sized brain takes it as ensuring space objects don't bump into one another. Why is this a specialized field of scientific knowledge? I would've thought it was elementary navigation or something like that.

Russell Boyce

One would think that a satellite or even a piece of space junk orbiting the earth is just up there in a very predictable orbit, but it's not. That's because the space environment is very, very unpredictable. For example, in low Earth orbit, it's not a vacuum. Space objects are in a very rarefied, admittedly, but still an atmosphere, as they do laps at extremely high speed; Sydney to London in 45 minutes. They are constantly being hammered by air molecules and that induces a drag. That drag ... or just like an airplane. If you have a strange-shaped object, there'll be strange forces built up on that object in different directions.

Michael

So this area of orbit, you said, is not vacuum. It's still partial vacuum, is it?

Russell Boyce

That's correct.

Michael

God, wow, there you go.

Russell Boyce

The atmosphere doesn't suddenly stop, although it drops away in an exponential-like rate. But in low Earth orbit, you very much have to worry about neutral and charged particles. The charged particles make up what we call the ionosphere, which is actually an aspect of space situational awareness. Our JORN, Over Horizon Radar Network, uses the ionosphere to bounce radar waves over the horizon. Space objects orbit in that environment and it fluctuates in time. It gets very, very crazy whenever the sun gets active. Space weather drives what happens up there. In fact, space weather can not only induce fluctuations in the behavior of satellite orbits, it can even take them out completely.

Michael

Heavens. So, there are presumably uniquely qualified space meteorologists, I'm guessing, Russell, just for this space weather predicting. Sounds very important.

Russell Boyce

That's actually part of Australia's very, very fine heritage. During World War II, we had radar specialists who found themselves looking for useful things to do with their skills after the war. That led to the establishment of ionospheric capabilities using radar, radio frequency physics in Australia. Out of that came an enormous heritage of Australian radio capabilities including radio astronomy, and in turn understanding of ionospheric physics and space weather. We developed a thing called the Ionospheric Prediction Service which is now part of the Bureau of Meteorology. It's one of the finest space weather services globally.

Michael

I was going to ask. I'm going to ask a bit later what are the areas that Australian Space might move into, extant from actually being up there, but that's one of them. Much of your work, Russell, is far from just being theoretical. I believe you're hoping to maybe have done, flown actual missions using real hardware, in something called nanosat missions. What are they?

Russell Boyce

There's different sizes of satellites. The listeners would surely be aware of the biggest satellite that's up there that man has made, the International Space Station. A more typical satellite is probably the size of a bus or maybe a car. But as you step down in scale, you end up with microsats which are about the size of a washing machine, and then down to nanosats or typically cubesats, which is what we play with. They could be the size of a shoebox or maybe a little bit larger, a book carton. You can go down picosats. You can even go down to satellites on a chip which are very, very small, and there are some funny stories that can be told about those. But yes, we work with nanosats.

Michael

Is this simply because, as with all technology, it just seems to get smaller? Cars, washing machines. Why not chuck satellites in there? Is it as simple as that?

Russell Boyce

That's very much part of the story. It is a simple message. There is a paradigm shift that has been taking place over the last decade where the miniaturization of spacecraft using advances in electronics and the reduced cost of putting such a small satellite onto a rocket launch, which in turn has reduced the barrier to entry for countries, for organizations, even ... One case that I've heard of, a primary school being able to get a very small object into orbit. It doesn't actually cost that much these days. Such satellites in the early part of that paradigm shift were just toys, a little bit gimmicky. Let's put an iPhone in space or let's just put something up there and say, "Hey, wow. We've got something in orbit." But not very useful apart from educational purposes, which is actually an extremely important activity, but in terms of capability, not very useful. But that paradigm continues to change. Disruption continues to sweep across the space sector. And now we have the possibility ... well, not the possibility. Now we are starting to make advances on the early stages of intelligent constellations of many of these small, intelligent nano and microsats. That is truly a game changer.

Michael

Wow. You're outlining a situation where satellites are becoming smaller, cheaper, can do more, and are being put into orbits by an increasingly large and diverse array of players. No wonder something like space situational awareness is needed.

Russell Boyce

The US Air Force described traditional large satellites as single-point targets. It's easy to track them. It's easy to understand where they are. If you wanted to perform a nefarious act on them, well within the bounds of possibility. As we move towards constellations of hundreds and even thousands of networked small spacecraft which are able to act in intelligent ways, it becomes a very nebulous situation up there. Anecdotally, a former colleague or a colleague who used to be at DARPA, the US blue-sky Defense Advanced Research Projects Agency, his comment to me was with these future space capabilities, "good luck to the adversary who can track them." Because it's a very different proposition. In fact, that also does worry the likes of the US Air Force who lead the global effort to track space objects, to maintain the space object catalog, to predict collisions, and to prevent space conflict from breaking out. Space is an ever-changing and an increasingly complex situation.

Michael

Let's get to Australia's role in that situation. Hypersonics and SSA are just two of the areas that you've worked in extensively, Russell. Let's get to the crux of it. Why does Australia potentially have a part to play in such fields? What makes us well situated to go into these fields?

Russell Boyce

We have some interesting advantages. One of the advantages is that we have not been doing much in space or in what the typical listener would consider to be space, as in technologies in orbit. We've not been doing much of that at all while most of the rest of the world has been doing quite a bit. One might consider that to be a disadvantage, but actually we come baggage-free. We have a clean sheet of paper and we are well positioned to take advantage of the paradigm shift that I was describing before. And also well positioned to play in the fringes or the crossover regions between space technology and other domains. That's the sort of activity where true disruptive innovation can take place, which in turn can lead to opportunity.

Russell Boyce

For example, it's not just about putting a satellite with an onboard sensor and a communication system into orbit. The future will include putting such satellites that also possess onboard artificial intelligence capabilities. They may well be quantum-enabled. They will be autonomous systems. In fact, they will be trusted autonomous systems. Australia has rich heritage and world leadership in those parallel and intersecting domains, which is a fabulous opportunity for us as a nation, with that clean sheet of paper, and with that rapidly evolving and shifting space paradigm, to jump in and become a world leader in some niche areas.

Michael

I'm going to be an awful wet blanket here and give a reality check. Far be it for me to dwell on the negative, but one of the recurring themes we've discovered in this series of *Conversation on the Runway*, the space episodes, for many eminent speakers such as yourself, Russell, is the story of opportunities lost in terms of our space industry going way back to ... but not confined to Woomera, the Cape Canaveral of the South, as one of them described that it could've been, lamenting. Russell, has anything changed in that field? Is anything changing? Car industry, medical research, manufacturing, renewable energies. One would hope to see space added to that litany of 'what might have beens' due to Australian, well, lack of leadership and lack of confidence, is how I would put it. What's your thoughts on that?

Russell Boyce

I think we face the same risk today with the space industry. However, we're not 10 years down the track regretfully looking in hindsight. We're at the beginning right now, and we do have the opportunity to avoid that risk. What do I mean by that? I believe that if the Australian government, the Space Agency, Defence, were to set about throwing money at developing an industry without thought for what is the difference between a space capable industry, an industry that is technically skilled at doing what it does just like the rest of the world. What's the difference between that and a potentially commercially successful space industry? Noting that the rest of the world has been playing the game for a lot longer than us and are highly motivated to keep winning in that game. How is our young space industry going to commercially succeed? I believe the answer to that is in those crossover activities, the combination of space in areas like artificial intelligence. In funding the sorts of push-the-boat-out space activities where even if we made mistakes, and we probably will, we make them fast, we learn from them fast - and disruption comes. Creative innovative ideas that can position Australian organizations to actually win in that game.

Michael

Surely, Russell, education. If the vagaries of government in the industry, commitments to industry such as space, remain difficult to determine, education for a space future remains a field perhaps that we can begin to establish. I know this has been the nature of much of your work. Do you think education is one of those cornerstones to an Australian space future?

Russell Boyce

Absolutely. Not just teaching the kids of today STEM subjects and not just belabouring the old phrase that space is one of the two areas; space and dinosaurs are the two things that get kids inspired. Kids these days, young people these days, have no need of inspiration. Young people these days, I'm quite astonished but excited at how deeply they think, how inspired they are, how much they want to change the world and have deep impact in very, very positive ways.

Russell Boyce

Where I see education coming into that and the crossover with space, is that space is not actually a discipline. It's not maths, it's not engineering, it's not science. Space is actually a domain. And that domain is very complex. To successfully utilize it, to put technology into orbit, to derive information from it, to use that to solve problems, to do so responsibly, ethically, it requires all disciplines and it requires complex thinking. And it requires leadership. What I personally believe is that if we can bring kids into education focused on space, we have an opportunity not just to solve technological problems of the future, but to actually build the critical thinking future leadership that this country needs.

Michael

Well, what you've just said is completely in line with what we've discovered on this series. To my delight, I have to say, some of the most erudite speakers on space have not been engineers, have not been scientists. They've been ethicists and historians, even archaeologists we've had. People who have a very strong vision, not just for space but for Australia in space. I know you do too. You've developed a Masters program which I believe is unique, and by which you're hoping to make Canberra a leading provider of the space education worldwide. Is that where one of our space future roles lies, Russell? Not just as being space educated, but Australia being space educators for the rest of the world?

Russell Boyce

Australia, one of our top export earners is education. As we come to this essentially a new area of activity for the country, as we build expertise based on that clean sheet of paper and therefore creatively build expertise and new ways of thinking, and as we embrace not just the tech heads but also the historians and the ethicists, and so on and so on. I think Australia and Australians will be building a level of understanding and perception and thinking about space which will be quite sought after globally. We have that opportunity and it's within our grasp to create education programs to deliver that thinking. Given what we're seeing this year in particular with COVID, with the need to be embracing online delivery in more and more sophisticated ways, there's nothing preventing us, apart from ourselves, in global delivery of that capability.

Michael

The importance of space, as someone said, is not what's in space, but what's done with the information gained from space. You mentioned weather before, which I haven't even thought of. Can you think of any other indigenous space capabilities that we might be developing here? Not directly related to launching necessarily and...

Russell Boyce

One of the things Australia is actually known for around the world, because we haven't had space technology in orbit of our own, we've had to use other people's, we've had to access other people's space systems and use the data that come from those. We've become extremely good at processing data from other people's space systems, and not wedded to one particular space system. Australia has a very, very thriving world-class downstream sector. By downstream, I mean the part of the space sector that is not the satellites in orbit, but it's the process of turning data into information for terrestrial outcomes. That can be for emergency management, or environmental monitoring, or for national security reasons. Whatever the purpose, we are extremely good at it and that's where the money is. And that's where Australia's focus should actually be.

Michael

Let's see if we can harness this already existing industry that we have as an international education destination. Unlike what we did a few decades ago with Australia being a nascent space sub-prime player I'll say, when we had Woomera, let's see if we can harness this. But Russell, we did, having put Australia at the forefront of the space race, let's present you with a scenario and some emergency, say we can envisage, pertaining to an Australian space industry of the future, coming to the rescue, a la as aforementioned, Thunderbird 3, the International ... what I thought was going to be something like the International Space Station meets the International Rescue sort of thing. But as you pointed to me beforehand, Russell, there are in fact other equally dramatic scenarios but not nearly as farfetched, and not so welded to an as yet imaginary future. You pointed out to me before we came onto the show a scenario evolving perhaps as early as the end of next year in reality, with a nefarious non-government actor deciding to act against a satellite. The first stage of this scenario, you pointed out, could play out in New Zealand. Let's go into that for a little bit, shall we?

Russell Boyce

It's not just the very large players such as NASA who have the capacity to reach orbit.

Michael

As we've been discovering.

Russell Boyce

There are some very fine organizations and companies around the world who can launch rockets into orbit. It turns out that in New Zealand, there is one of them, Rocket Lab. It's actually an American company but based in New Zealand for the most part.

Michael

Whereabouts?

Russell Boyce

Their headquarters is in Auckland.

Michael

In Auckland, okay.

Russell Boyce

They launch their rockets from the Mahia Peninsula, about halfway between Napier and Gisborne on the east coast of North Island.

Michael

Gotcha, ok.

Russell Boyce

Rocket Lab are a commercial launch organization. It could be possible for a customer to come to Rocket Lab and say, "I would like to launch a satellite into orbit." A small spacecraft up to 150 or 200 kilograms, so something the size of a washing machine. In good faith, Rocket Lab could launch that satellite.

Michael

What sort of permissions? Are there international ... Let's go back to what we've learned about space law. Are there international permissions that Rocket Lab, say, would have to acquire internationally before launching said customer's payload?

Russell Boyce

So, Rocket Lab requires the permission of the FAA in the US, and also the New Zealand government. Imagine there was an Australian organization such as my team, which is launching a pair of satellites on Rocket Lab in February next year. We also need the permission of the New Zealand government, but we need the permission of the Australian government. In theory, everything is...

Michael

Just quickly, the FAA, just tell us who they are. Remind us the FAA is ...

Russell Boyce

I'm sorry. The Federal Aviation Authority in the US. So they are the ...

Michael

That's like our CASA.

Russell Boyce

Correct.

Michael

They give it the tick off. Perhaps the people pressing the buttons on that little peninsula on the North Island of New Zealand don't ask too many questions when something is in space, but it ...The intentions of our said nameless customer are slightly more devious and it is something to do with commercial advantage over a rival. This is the scenario we're painting here.

Russell Boyce

I should stress, no slight to Rocket Lab and they do ask all the questions, but just imagine something slipped through.

Michael

Sure. They're only human after all.

Russell Boyce

These days, it's possible for commercial players, or for organizations all around the world to access space and to get substantial spacecraft into orbit, potentially beyond the control of governments. Those spacecraft increasingly have technological capabilities to be able to be somewhat maneuverable and to sneak up on other people's satellites.

Michael

And be disrupting, let's say.

Russell Boyce

And be disrupting. This approach is being used for good in an effort by several players around the world, to be servicing existing satellites to ... to fill up their fuel tanks, to prolong their life in orbit, which is a great thing. But it's also possible to get up to nefarious activities. SO imagine we project forwards, potentially even some decades, when Australia may be part of a coalition that is involved in lunar activity, possible Martian activity. There's a lot of talk about setting up bases on the Moon as a stepping stone to bases on Mars. There's talk about off-Earth mining, utilizing the resources that are out there on the Moon and asteroids and so on.

Russell Boyce

Whatever one might think from an ethical and code of conduct perspective about whether we should do that or not, let's imagine that we do do that and that Australia is part of such a coalition. You would think then, that within the realm of Australia's national security, national interests, to be part of the protection of those activities, even though they're no longer on earth. Imagine we're part of an international coalition that for the most part doesn't involve astronauts in orbit, because human space flight is a very, very dangerous and expensive thing to do. It's far more easy and far more effective to be flying robots. That's not science fiction. That's the near-term future. Imagine that that future scenario involves autonomous systems where Australia is contributing our expertise in remote operations in the resources sector, for example, and we are actively pursuing that for space now, then it could be that the Australian Defence Force of the future, with space technology-

Michael

I was hoping you were going to lead to that. Go on.

Russell Boyce

To actually find ourselves part of an effort to counter a threat from a nefarious actor trying to disrupt.

Michael

Say this satellite that they're wishing to install, say a rival satellite to the corporation whose equipment they have damaged or taken offline or whatever, and an international situation is created, would it be our hardware? Would it be our Tidbinbilla or our Parkes? Or anything like that? Would it be our intellectual prowess? Would it be our space knowledge that would be immediately brought to the fore to resolve this situation? Would we be called upon by the big prime players, "Look, we need you." Just like they did in 1968. We've all seen The Dish. Are we more equipped today to handle assisting with a situation like this than we were back then, Russell?

Russell Boyce

In some ways we are more equipped. Let's consider the obvious communication issue in the famous movie The Dish. We used our capabilities at Parkes and also just outside of Canberra, Honeysuckle Creek, for communication with the astronauts on the Moon. The dish at Tidbinbilla, just outside Canberra, the very big dish is one-third of NASA's global deep space network. If there's any lunar or Martian or other activity in the future, Australia would definitely be involved in that. Hopefully not just with radio capabilities, but in the future with laser capabilities for optical communication. That's one aspect of the way we would be participating in solving the challenging scenario we described.

Russell Boyce

But we now bring to bear capabilities from left field. I mentioned our remote asset management capabilities from the resources sector. Australia has the two largest mining companies in the world and those companies, and others in Australia, have led the way in developing robotic remote operations in very, very nasty challenging environments. We are well equipped to firstly contribute to the development of technologies to do that in space. Not just mining in space but in general, remote operations of autonomous systems. But if something went wrong and we needed to troubleshoot, we needed to come up with solutions to a very challenging problem in rapid time, it may be that we are amongst the best equipped in the world to draw up on our experience and come up with those solutions in time of crisis.

Michael

This is painting a very rosy picture. I often like to ask my guests if they are optimistic or pessimistic particularly about an Australian space future. I think I'll put you in the latter camp, which is great to hear, Russell. This is a scenario far removed from that lost industry that we alluded to before, after the heyday of Woomera. As an educator, are you seeing the interest in space on a real level, beyond just the rocket ships and dinosaurs, coming up from young people who will be our space players of the future? I actually want to quote from the descriptions of one of your education platforms directly, if I may: "The space missions will be underpinned with world-leading ground-based experimental research employing space test chambers, advanced diagnostics, and supercomputer simulations." And this is all happening in Australia, Russell.

Russell Boyce

It is. The fact that we are setting out to not just use space-derived data but to get our hands dirty with satellites and in turn to train others, particularly in the Defence Force, the art of space missions, of satellite development, using the educational tools that we've developed here. Tools for analyzing orbits, tools for ... well, in fact, world-class tools for designing missions and satellites. The fact that we're doing that is very important and we're seeing a lot of focus coming on to our group and the efforts here at the Australian Defense Force Academy. We're engaged in a lot of conversations particularly with young people, particularly with those in the rapidly growing startup sector in Australia. In fact, Australia has the largest rate of establishment of startups in space of any country in the world.

Michael

Australia has the largest ... Just say that again because that does astonish me and it delights me too. Just repeat that, Russell, so I can hear it again.

Russell Boyce

Australia has the largest rate of establishment of space startups of any country in the world. I've lost track of the numbers this year. We have well over a hundred startups. It's probably many more than that now.

Michael

These are small concerns, every concern starts small, of people getting together with a brilliant idea of how we can interact in this country with space, putting it in the most simplest terms.

Russell Boyce

Correct. Some of those ideas, some of those startups will fail because that's just the nature of...

Michael

All startups.

Russell Boyce

... being an entrepreneur.

Michael

Yes.

Russell Boyce

On the other hand, some of them are clearly succeeding. There's a handful of examples in Australia of small companies that are starting to get significant traction and growing at a rapid rate.

Michael

In what sort of areas, may I ask, is the real international interest being directed to? What is the nature of our space interaction that is grabbing that attention? Is that a satellite manufacturer? Launch systems?

Russell Boyce

Yes and yes and yes. I'll give you a couple of examples. In the increasingly important field of Internet of Things, there are at least two very successful companies in Australia. One is called Myriota; the other is called Fleet. They are coming at the Internet of Things employing space technology from slightly different directions and they're both proving to be successful. There are small companies who are developing downstream applications, turning satellite, particularly imagery, data, into information to solve problems. There are companies starting up in Australia to develop for the needs of defence, for example, ISR capabilities: Intelligence, Surveillance, and Reconnaissance. There are launch capabilities developing.

Russell Boyce

We'll see whether any of those are ultimately successful. There will be significant commercial forces acting against them because they'll be competing globally, but the rate of establishment of these companies is astonishing. The reason I brought this up is that those young people starting those companies, they recognize the skillsets that they need. They recognize the need for education and experience. The work that my group and others around the country are doing to firstly, gain experience ourselves and secondly, seek to transfer that experience and that knowhow via education into the hands of these people, is extremely important.

Michael

What a wonderful note, I think, to round out the discussion. I love that optimism that you present Russell. It's good to know that in your esteemed opinion, we do have a strong Australian space future if we get things right, if we continue to get the societal and governmental and commercial support that something like a space industry in a country such of ours, must surely need.

Russell Boyce

Absolutely. I am very optimistic. I do caution that Australia should not just blindly shotgun-style throw money at industry at large in the hope that we will grow enough companies to take our ... claim fair share of the global space economy in proportion to our GDP share of the global economy. I don't think it works that way. We've got to be cleverer than that, and we've got to put the money at the areas of activity where Australia can truly lead. We're not fighting against highly motivated incumbents in the global space sector, but we're creating those new areas of the market ourselves.

Michael

Russell, what you've just told me about Australia's importance in the global sphere, I had no idea the importance of Tidbinbilla and Honeysuckle Creek in the ACT. Just remind us what proportion you said of America's ... was it their Deep Space Program is provided by us?

Russell Boyce

NASA's Deep Space Network, the communication network that enables comms with spacecraft traveling towards the Sun or to Mars or out past Neptune, et cetera - one third of that network is based just outside of Canberra at Tidbinbilla. In the Apollo days, it was Honeysuckle Creek and also Parkes, but these days the communications is at Tidbinbilla. It includes some of the assets that were at Honeysuckle Creek, but plenty more. And in fact, just to make a link for you with space situational awareness, space situational awareness is usually thought to be trying to understand potential collision between space objects, between satellites. In actual fact, another form of collision is between an asteroid and the Earth, and so there's a lot of effort made to track near-Earth objects, asteroids that come uncomfortably close to the Earth.

Russell Boyce

In recent years, my group worked with CSIRO and DST and NASA's JPL in some research where the big dish at Tidbinbilla, and the big dish at Parkes, were turned into a radar system. Radar waves were transmitted from the big dish at Tidbinbilla, aimed firstly at the Moon to calibrate them, but then when we used 'in anger' it was aimed at a passing asteroid, and the reflected waves collected by the dish at Parkes, and were used to characterize trajectory and ... with advance signal processing, even extract information about the behavior of the asteroid in terms of rotation and so on.

Michael

Where was this asteroid? How close was it coming to us?

Russell Boyce

Well, it was well outside the orbit of the Moon, so it wasn't close, but..

Michael

That's close enough for me, I have to say.

Russell Boyce

Occasionally, big objects do pass between the Earth and the Moon. I know that there is one coming seriously close some time in the next decade which space scientists are very excited about, but others...

Michael

You're just telling me this now, Russell. Now you got me worried. Is there a name or a number? Maybe it could be Russell Boyce 260 or something like that, you have it named after yourself.

Russell Boyce

I believe it does have a name. I don't know what it is. I'm certain it's not named after me. But this is part of ... Well, what an incredible universe and what an incredible world we live in. How cool is it that we're capable of asking questions and seeking answers and stretching to be better and better as a human species. What we've talked about today is just various examples of that. It's quite exciting.

Michael

Very, very cool. Russell, I fully agree with you there. I can see you're going to be very busy over the next few years, Russell, but space education has to start early, surely, than the postgraduate tertiary sector. Am I right? What's being done with younger children? Particularly in regional areas of Australia.

Russell Boyce

Michael, let me give you two examples. And you're dead right, it's got to start with younger people. The young kids in the regions are just as talented as the ones in the cities, possibly more open-minded. Some years ago, there was a ... under a thing called the Australian Space Research Program of ... an excellent program was funded called the Mars Yard at Powerhouse Museum. Part of the funding of that, including support from NBN, was to be able to pipe Mars landscape and remote operation of rovers and analysis of Martian imagery from NASA to support real research. That was piped through the internet to regional schools to very, very good effect. That's one example. As another example, another one of the hats that I wear. I am the Chair of COSPAR 2021 which will be the world's largest space research conference ever. COSPAR is the Committee for Space Research. It was set up in the '60s, I think, the international peaceful counterpart to the US-Soviet space race. Every two years they have this ginormous conference. It's never been to our part of the world ever. We're holding it in Sydney in January, but because of COVID, we're mostly virtual.

Michael

I see.

Russell Boyce

Despite COVID, we're seeking to add value and leave a significant STEM legacy through a space STEM park on site in Darling Harbor, but virtualized, so that we will be able to pipe, particularly out to the regions and particularly with the support of the New South Wales Department of Education - which in turn I learned recently has the second largest school jurisdiction in the world - that's an aside. We'll be piping a space journey with virtualized hands-on education opportunities for teachers and school kids to schools across New South Wales at least, potentially all of Australia, and potentially even globally. It's a very, very important thing to be doing and we're seeking to do it and to hopefully start a tidal wave.

Michael

Wow. It sounds very exciting, space future for young people in very good and safe and creative hands. If I may stick a feather in our *Conversations on The Runway* cap, I believe the curator of the aforementioned Mars exhibition that you so described, Russell, at Powerhouse, was done by one of our previous guests here on the show, Kerrie Dougherty, whom you no doubt know.

Russell Boyce

I do know Kerrie. Kerrie was involved. A partner in crime of hers, Carol Oliver, from my university but in Sydney, was the lead for that.

Michael

We'll grab her for our next series. Don't you worry about that. No one on *Conversations on The Runway* who knows anything about space gets out of here alive. Professor Russell Boyce, it's been absolutely wonderful talking to you today about Australia's future in space. What we're doing, where we're heading, I really like the tone of your optimism. If you were the boss of everything in, say, 20 years time, if there's one thing that we could have established, what would make you very happy to see it in this country space-wise?

Russell Boyce

I would like to see, and in fact I'm intending to make a start on it, I would like to see a national program developed for students, for at least secondary students, high school students, and university students, to get their hands dirty in space activity. So, something like a national innovation challenge for space. But one that is designed a little bit differently to what the rest of the world might do, where they have competitions for space missions for students.

Russell Boyce

It's not realistic that a future Australian space economy is manufacturing hundreds of thousands of satellites; the market's simply not there and never will be. What is realistic is very, very large numbers of highly-skilled future workers turning data into information from space systems, engaged in developing artificial intelligence systems. I can see the opportunity for a national program that offers a small amount of hands-on space hardware experience, but more importantly, a large amount of opportunity for students to create algorithms, artificial intelligence capabilities, upload them to satellites, turn data into information on the satellites, and become directly connected into the real opportunity for Australia that lies ahead.

Michael

What a terrific aim to work for. Professor Russell Boyce of the University of New South Wales Canberra, thanks so much for your time and your expertise today on *Conversations on the Runway*, our final episode all on space.