ROYAL AUSTRALIAN AIR FORCE

Transcript

Conversations on The Runway - Space Series Episode 1 – 'Space Explained'

Host: Michael Veitch

Guests: Dr Melrose Brown and WGCDR Steve Henry

Michael Veitch:

So, to kick things off on Conversations on the Runway this week, I need to make a bit of a confession. One which, for reasons that will become obvious, I don't tell many people. So, here we go.

OK. So, growing up I was, well, a bit of a Trekkie. There, I've said it. Outed myself. It feels good. Actually, bit of a Trekkie doesn't quite cut it. I was obsessed. Watched every ep of Star Trek, many times, from the first episode aired September 8, 1966 to the very last one, June 3, 1969. Plus Next Generation, plus all the movies, even the crappy ones. Pretended to be Spock at school, dressed like Scotty can you believe it? And once I even went to a convention. Yeah, I know.

So, it's off my chest. Now it's your turn. Was Star Trek your thing? Was Kirk or the alluring Lieutenant Uhura your pin-up? Maybe you're fonder of its nemesis, Star Wars or even The Jetsons? Lost in Space, maybe? The silliness of Blake's 7 or the mastery of 2001: A Space Odyssey? It doesn't really matter, because the point I'm trying to make is that every one of us, I think, thanks to popular culture has grown up with some idea, some image of what space must be like, and all of those images and ideas I'm guessing are completely and utterly wrong.

My name is Michael Veitch, your host for Conversations on the Runway, and over the next few weeks there will be no limits, literally, to our discussion, because we are taking you into orbit with some very clever people who actually know some really amazing stuff about space and particularly what military conflicts might look like in space if indeed they're not already happening way up there above our heads.

We'll take a look at the weapons, the players - it ain't just the Russians and the Americans anymore I can tell you. The brain-bending physics, the fascinating legal aspects, today's satellites - did you know they're the size of a loaf of bread? And just how far we've come in a very short time and where to from here.

Space and war, is it even possible? Many people think it's the new frontier of military thinking, and if so, Australia will have its part to play.

Wing Commander Steve Henry is Commanding Officer of the Surveillance and Control Training Unit up at RAAF Williamtown and who has also spent a bit of time in the Pentagon - I'll be asking him about that, that's for sure2. He'll be joined by his good buddy from the University of New South Wales in Canberra, Senior Lecturer in Space Situational Awareness, and Head of the Space Masters Program, Dr Melrose Brown.

So gentlemen, let's boldly go ... Oh, shut up. Gentlemen, welcome to The Runway. How are you going, guys?

Steven Henry:

Excellent. Very good. Thanks a lot.

Melrose Brown:

Excellent.

Michael Veitch:

Good stuff. Melrose, I'll start with you. A couple of the basics. Now, I'm not going to ask you to tell me where space ends. That would be kind of surreal. But can the world agree, from Earth's perspective, where does space actually begin?

Melrose Brown:

That's a very easy question to answer. The answer is ‘no’. It is very hard to determine where space begins, because there isn't an easy legal definition of it, and from a physics definition, it really depends what you're trying to use space for. You can think of space as being a point very high above earth. So, you could go up in a balloon and get really high above earth, and that's much atmosphere there.

Michael Veitch:

And the balloon can only go so far.

Melrose Brown:

That's true.

Michael Veitch :

It can only go so high.

Melrose Brown:

That's true. Or you could have a theoretical elevator that'd take you 800 miles above the surface of the earth. You still wouldn't be in orbit then. You would be in the space environment, but you wouldn't be orbiting in space. So, you thought you'd start with an easy one, but that's actually one of the most vexing questions. Certainly once the discussion moves into things about regulations and laws and things, it is a very fuzzy line.

Michael Veitch:

I've been learning about GEOs and LEOs, different types of orbits. Steve, what's a LEO and what's a GEO?

Steven Henry:

LEO is - low earth orbit, and as the name suggests, it's pretty much the lowest region of space that we tend to orbit in. A popular definition, certainly one that Defence uses is about 100 kilometres - and we can talk about why 100 kilometres - out to 2,000 kilometres. You've got nice low satellites there. They're moving quite quickly, so they're not persistently over any one point. But being close, that's the best spot to get images from for example, because you're as close to your target as you can get to take a photo of it.

Michael Veitch:

So what's the kind of bandwidth around the earth in which satellites and other things are circling the earth? Does it start at a 100 km out and go to that 2,000? Or is it a bit more complicated than that?

Steven Henry:

There's certainly plenty in that band, and that's getting to be a more and more congested band, especially in particularly useful segments. I think Elon Musk is putting his Starlinks at various altitudes between 550 to 1200 kilometres depending on coverage and that sort of thing. So yeah, but then it sort of thins out a bit to 2,000 kilometres. Then the next band you already mentioned is GEO, Geosynchronous orbit, at 35,786 kilometres, which is a very particular altitude.

The reason that's there is because a satellite orbiting at that altitude actually orbits the earth once every solar day. So, it follows the earth around at the same speed as an orbit. So, it appears fixed in the sky above a point on the equator. It's pretty nifty. Sorry, what I should mention is between LEO and GEO, everything in between there, between 2,000 and 35,786 is known as MEO. Yeah, that's medium earth orbit, and that's where, about halfway out, at 20,000 kilometres altitude, that's where you'll find useful constellations like GPS.

Michael Veitch:

At what point going straight up do you start to lose the effects of earth's gravity? At what point, beyond which, will something not necessarily pull you back to earth? How far do you have to be out?

Melrose Brown:

This is one of the big things that we need to tackle on the physics front.

Michael Veitch:

I'm glad you said that, Melrose.

Melrose Brown:

Because you're in space -

Michael Veitch:

I'm glad you said that.

Melrose Brown:

... doesn't mean that there's no gravity. To be free from gravity, you would need to be in the deepest, darkest corner of the universe where there is no body with any mass at all, and then you wouldn't have a gravitational force acting on your body.

The reason that you're in orbit isn't because there isn't any gravity. It's that you're going so fast that instead of falling down to the earth, you start going in circles. So, a more correct term to think about being in orbit isn't weightlessness or a lack of gravity, you're in free fall.

So a classic way to think of this is if we go back to the big elevator that we thought of earlier. So, you're 500 kilometres high on your elevator. If you threw a baseball and you threw it as hard as you could - I'm not particularly strong, so it wouldn't go particularly far - gravity would catch it and it would re-enter. It would come back onto earth's surface. If you keep throwing it harder and harder, it would go further and further until you get to a point where gravity would try to pull it down, but you've thrown it hard enough that it wouldn't re-enter to the earth. It would just keep going round and around.

It's the velocity that you're traveling at that determines what orbit you're in and what altitude you're at. The velocity that your object's going at is really related to the amount of energy that you need to be there, and that's what makes getting things into space hard. So, if you've got a very light thing, so say a cube-sat that we were talking about before, the size of a loaf of bread - doesn't weigh particularly much. So, you need a lot less energy to get it up to a speed where it will orbit. If you're talking about a two tonne satellite that's the size of a double-decker bus or whatever, then you need a lot more energy.

Michael Veitch:

Hence why the Saturn V rocket, half of it was just fuel, basically, that pushed the thing up.

Melrose Brown:.

Exactly.

Michael Veitch:

Well, I'm glad my brain is not bending into oblivion with this discussion. So, thank you gentlemen for bearing with me in those questions that are probably far below your pay grade.

To man's involvement in space, it's been, what, 50 years since Apollo 11 and the day Neil Armstrong uttered those wonderfully misheard words as he stepped off the LEM and onto the Moon. I've been told, and Steve, it seemed a bit of a cliché, that the mobile phone in our hand has a greater computing power than anything he and Buzz and Mike Collins had up there. Is that true or is it a myth?

Steven Henry:

No, it's absolutely true strictly in terms of processing power, but I guess the counter to that question is: Does a machine used to land something on the Moon have as much power as something used to watch TikTok videos?

Michael Veitch:

Of course, back in the 60s only the brightest and best were given the use of such computing power.

Steven Henry:

The thought process on that goes even further. When they were designing the Apollo landers, whether or not to include a computer on that lander was a decision that they had to make. Whereas you would just assume, "Hey, there's going to be a computer on that today," that was a conscious decision at that time to include a computer on that satellite. That's how early it was. It's very, very impressive.

Michael Veitch:

The Apollo missions were of course a race to get to the Moon. Was it also the beginning of our colonisation, if you want to use that word, of space? Is that what kicked it off or had it already started?

Steven Henry:

I think the US just wanted to get a run on the board in every regard in the Moon race, sorry, the Space Race. As it was, they'd been beaten by the Russians up until that point to get an object orbiting, to get a human orbiting, in several other regards. So the Moon really was one of the last things they could do that could be an actual first for the US. So in terms of national power, not necessarily military power, it was a huge statement and a big goal for them.

Melrose Brown:

Yeah, I think that's a good point, and it does highlight really the change that's happened between the late 60s and where we are now. Back then, certainly going to the Moon, going to Mars, having a human footprint on other celestial bodies was a really big focus both strategically, but also for national pride and also advancing what the human race is.

Michael Veitch:

I was going to say there was an existential element to all that, wasn't there? I mean I've just been actually reading a book about Antarctica, and the similarities between space and Antarctica back then for humankind were quite similar. It was a vast unknown space, and no one was quite sure of the point of getting there, but getting there we were determined to do.

Melrose Brown:

Yes, I think the point of difference I would make on other planets compared to Antarctica or even deep sea diving is that Antarctica and the bottom of the ocean, we know that there's life there. We know that there's life on earth. But one of the really big questions that we've asked for a very long time is, is there life on other planets? It's very unlikely you're going to just bump into ‘Bob the alien’ on Mars and have a conversation with them. But a really, really big question is are we the only life source in the universe or are there others?

Michael Veitch:

That old one.

Melrose Brown:

Yeah, that one. Those were the sorts of questions that were really being asked back in the late 60s, and we thought we could answer them. But as you move through into the 80s and 90s, they really pulled back from exploring the Moon and Mars, and it really focused on the space station. Humans still in space, but orbiting quite close to earth. It was pulling back to be more of an earth-centric focus rather than that exploratory focus, and now we see this big push again to, "Let's put people on the Moon and let's try and colonise Mars". It's kind of come full circle I guess.

Michael Veitch:

Well, for many, the Apollo era was a seminal moment for all of us who are old enough to remember it. Another surely was, I think - and this brings us into the discussion of human military interaction, human foibles, call it what you like - the first Gulf War. Who can forget those TV images of satellite technology giving us precision weapons and real-time intelligence and vision? A quantum leap from anything we saw on Apollo. But that was, of course, 20 odd years ago. Has the technology and the science continued to evolve exponentially since that time?

Steven Henry:

I would say absolutely yes. Not just in terms of capability, but in terms of employment and people understanding how to use it. In fact, in many regards, military strategists now consider space to be somewhat of an Achilles' heel for modern military forces. We've become so heavily dependent on it, and that is something that is obviously an issue to be actively avoided. You never want to create a weakness in your military system. So, as much as space systems are flash, it's important to make sure that they are also resilient and that your systems that are supported by them are resilient as well.

Michael Veitch:

To the militarisation of space, I read in the intro to the Centre for Strategic Studies recent volume entitled Space Threat Assessment 2020, there's a US Army General quoted as saying that quote, "Every company commander depends on space today and takes it for granted." Is that true, gentlemen?

Steven Henry:

I would say absolutely yes. GPS is a great example. GPS, it's the US Global Positioning System, and it's one example of a global navigation satellite system. So, the Chinese have BeiDou, the Russians have GLONASS, the

Europeans have GALILEO. So, there's several of these systems around. GPS is not a generic term. It's a particular system.

It's a timing signal, and that's a really important thing to remember is that it does triangulation by timing. When they talk about it being a positioning navigation and timing signal, the timing piece is often forgotten. You think GPS, you think location, but it provides synchronisation timing for secure communications, for internet services, for ATMs. All of these different things. So it's a really, really pervasive technology. Uber, UberEats, all that sort of stuff all rely on GPS.

Melrose Brown:

I think that's a really good point. It goes well beyond just a military context. There's certainly a lot out there about how much the military relies on space and how we need to be resilient from a military standpoint, but society depends on all of this stuff as well. So, how we do our banking, how we communicate, how we do pretty much everything precision. Agriculture, all of this really depends on space assets.

Space has always been this dual use realm where it's tightly coupled between the military and strategic needs, but also the civilian and government, and now moving into commercial needs as well.

Michael Veitch:

I guess military and civil technology has always gone hand in glove, particularly during the first and second world wars. I think it's fair to see the advances in military technology spilled over into the civil realm, if you like. Is it the other way around with space? Are the Elon Musks and the GPSs and the technology we use for UberEats, is that the kind of tip of the spear of space military technology?

Steven Henry:

So GPS is a military technology. It was developed initially by the US Navy, and it is now operated ... or the predecessor was developed by the US Navy. It's operated by the US Air Force as a global good. So I think people tend to forget that this is something that the US military runs every single day for free, for everyone.

Michael Veitch:

Does it?

Steven Henry:

Yeah, absolutely. So, it's an important point to remember, and I just want to go back to Melrose's point there about dual use.

It is an absolutely key fundamental point in all things space, that so many of the technologies are dual use. The same rocket that launches a dedicated military satellite is the same one that can do monitoring for humanitarian purposes, and the GPS that guides a weapon is also the one that guides an ambulance to an emergency or anything like that. So, dual use is an underpinning concept when it comes to space.

Michael Veitch:

Well, to that, let's talk about a couple of concepts, but I want to start with a quote that the UN General Assembly declared in 1958. Quote, "They wish to avoid the extension of present national rivalries into the field of outer space and that the exploration and exploitation of outer space shall be done for the benefit of mankind." How's that panning out, fellas?

Steven Henry:

Ah, gutters and strikes.

Michael Veitch:

I also note that 1958 was the first year that the Americans and the Russians first dabbled in ASAT - anti-satellite missile technology. So, from the get-go I think we can say that man's interaction with space has had a very strong military underpinning. Is that true?

Melrose Brown:

Absolutely, but to answer your question, I think it has gone quite well, all things considered. You know, we've had a lot of cooperation in space. So again, look at the space station. You've got all of these different nations of Russians and the US and lots of other nations now all working and living together on the biggest structure we've ever put into space. It weighs an awful lot of mass and it costs an awful lot of money to put up there. It's genuinely a beacon of

international cooperation. So, there is, in recent times, a lot of stuff in the news about struggle and potential conflict, but there has been quite a lot of cooperation. More cooperation than you would see in many other domains across the land.

It was really good that they came up with those rules and regulations back in the day when nuclear proliferation was a big concern, and there was a genuine concern that lots of weapons were going to be in space. I think there's a lot to celebrate from that, but it's going to be interesting to see what the future may hold for all of this activity.

Michael Veitch:

I remember in the 80s, again giving away how old I am, Ronald Reagan spoke much about his so-called Star Wars anti-missile system. It was considered one of the low points of his administration. It didn't go anywhere, because it was considered that the technology was simply far beyond what we could produce and far too expensive. How does that idea stack up today?

Steven Henry:

Technologically, obviously it would be more achievable today. Whether or not it would be great value or a great strategy is a very, very different argument. We sort of talk about the militarisation of space. I would argue that space has always been militarised. Even right from the start it was -

Michael Veitch:

Sputnik.

Steven Henry:

Yes, Sputnik was a pretty big statement and could be widely regarded as a middle finger to the US. I think the bigger concern these days is probably weaponisation of space rather than militarisation.

Michael Veitch:

Explain the difference if you could, Steve.

Steven Henry:

For sure. Militarisation, we talk about peaceful purposes. Putting a satellite up that can monitor what's going on around the world, a military satellite is a military purpose, but it's also peaceful. You could say that the Cold War was largely cold because of surveillance from space enabling or increasing trust in between superpowers. You can put plenty of military capabilities up, none of which are weapons.

Weaponisation I would suggest is where you start looking at kinetic and/or irreversible effects in most regards is how people would see it. Destroying things that cause debris. That is not the sum total of weaponisation of space. Most space weapons will not be kinetic in nature. It'll be activities in the electromagnetic spectrum - electronic warfare, lasers, and non-destructive forms of warfare like perhaps turning a satellite around so it's not looking where it's meant to be looking and messing with them in other ways. Because a kinetic war, a war that creates debris in space is very commonly acknowledged not to be in anyone's interest, because it trashes the space environment.

Michael Veitch:

So if you go and blow stuff up in space, as I understand, you'll not only wreck what's up there, but you'll run the risk of actually wreaking havoc on Earth as well.

But what about from space to Earth, for example EMS, EWs, lasers. Is it possible that in this 'space wars mix' laser weapons could be fired from space to Earth?

Steven Henry:

Conceivably yes, that is possible. Current technologies, though, in terms of just the huge amount of power that you would need to actually influence anything. If you were firing a laser from LEO, for example, you don't get a very long shot so it better be powerful. Whereas if you're firing it from GEO, you get all the time in the world, but you're so far away that it still has to be a very, very powerful laser to do that.

So, I would say that lasers, no. Electronic warfare to and from and between satellites? Absolutely.

Michael Veitch:

I learned recently that the US has already detonated nuclear devices in space. Is this true, gentlemen?

Steven Henry:

It is true. 1962.

Michael Veitch:

Really?

Steven Henry:

An operation called Starfish Prime or a test called Starfish Prime.

Michael Veitch:

That really does sound like a video game. I'm sure we can talk about things coming full circle in technology there, too. Starfish Prime. Tell us about Starfish Prime.

Steven Henry:

It was a nuclear detonation test conducted at 400 kilometres above the Pacific to see what that would do to a satellite. It was successful. It disrupted, I think destroyed the target satellite that it was going after, but the resultant electromagnetic pulse, and correct me if I'm wrong Melrose, cloud of electrons and charged particles that started belting around disrupted or destroyed many, many other satellites as well.

Michael Veitch:

Was there no danger of radiation falling back to earth and poisoning people and things?

Melrose Brown:

Presumably, but they were detonating nuclear weapons on the surface of the earth, testing around that time anyway.

Michael Veitch:

Yeah, absolutely. You let a couple off during your lunch break back then didn't you?

Steven Henry:

There was at times, yeah.

Michael Veitch:

Bringing us up to America's military involvement, I'm asking about this, because you've actually worked in the Pentagon, or been in the Pentagon. I thought Space Force was simply the title of a very amusing, funny spoof comedy show starring Steve Carell about the US in space, but no, President Trump signed it into being last December. There is a real Space Force. What's its purpose?

Steven Henry:

The purpose of the Space Force is, the way that the US put it, they were concerned that the US Air Force focused - they weren't solely focused on space I guess is the best way to put it. So, they wanted a General in charge who got up in the morning thinking about space, because that reliance that I mentioned earlier, and possibly Achilles' heel, was emerging as a real problem for a space system in the US that was developed when space was considered a sanctuary where you could put something up there, it would last as long as you wanted it to, because no one could touch it. Well, that has gone away, and many space actors have realised that their systems are not designed to deal with a dynamic and contested environment.

So the US decided to make a Space Force as a branch of the US Air Force still. So, just as the Marine Corps falls under the Department of the Navy, the US Space Force is part of the Department of Air Force. These are a group of space professionals who are dedicated to assuring space services and space control for the US military, and their allies I should mention, they are very, very strong on including their allies in that effort.

Michael Veitch:

Melrose, indeed. Not just the US, France wants to rename its Air Force the Air and Space Force. India has become not even the first, but I believe the fourth country to successfully test something called a direct ascent anti-satellite missile. Iran is involved, Japan, I'm having trouble keeping up. It's a bit like a kind of arms / space race of old. Is that a fair assessment, Melrose?

Melrose Brown:

Certainly there's a lot of activity happening in the military area, and the US has led with Space Force, and other people are responding. It does go hand in glove with the changes that are happening on the commercial front as well. So, in parallel with the formation of the Space Force, the civilian and commercial aspects of space traffic management, like you have air traffic management, are going to be passed to the Department of Commerce in the US. So that was previously a US military role where they would track everything in space and tell everyone where things are and give you a heads up if you're going to get hit by a bit of space debris or someone else's satellite.

With the vast increase in the number of commercial satellites - I think already over 50% of the satellites in space are commercial satellites - and when we grow from 2000 active satellites today to 20,000 satellites, active satellites at the end of this decade, which isn't that far away.

Michael Veitch:

Can you say that number again, please Melrose?

Melrose Brown:

So currently there's 2,000 active satellites in orbit in space. So, that's ones that work. Everything else is debris. Over the next 10 years, that number is going to grow by a factor of approximately 10, and the vast majority of those will be commercially launched and owned satellites. So, it's becoming a contested and congested environment, but the other word that's used a lot in this area is competitive.

The commercial sector is going really, really hard to try and gain as much financial reward as they can from the space environment, and that really changes the picture a lot. You've got a lot of changes on the military front, but you've also got a lot of changes on the civilian and commercial front. And these two areas need to work together hand in glove, so that we have a very safe and sustainable space environment so we don't have accidents or we don't have legal litigation when people get in the way of each other. So it's a very interesting time to be around.

Michael Veitch:

Indeed. The SpaceX company, I believe, alone has 300 of them up there, and that's just one company.

Melrose Brown:

So yes, that's Elon Musk's company. SpaceX has really pushed the boat out a lot in defining what commercial space means. One of their big headline technologies is reusable rocket stages. So instead of throwing everything away and you've got to make a new one, returning and landing stages of your rocket and refitting them, and then you can go and launch again. That brings the cost of launch down significantly, and that means it costs you less to put things in space. So, you can put more things in space.

Importantly, Elon, that 300 is a very small number of his plans. Thousands and thousands of satellites he will be launching in the next few years.

Michael Veitch:

Steve, weren't you telling me that Elon Musk wowed the world when they said you can't possibly deploy that many, and he proved them wrong.

Steven Henry:

Exactly right. We’re used to, as these launch capabilities developed, we're used to launchers putting up one or two major pay loads at a time. That's just sort of where the thinking was until quite recently. Now, launching multiple satellites on a launcher isn't all that new, but launching quite this many 200 kilogram satellites at a time ... and I can't remember the exact number now. I think he was launching about sixty at a time. Sixty 200 kilogram satellites per launch.

We looked at it before and said, "12,000. Well, that's going to take you six or eight thousand launches or whatever. That's just ridiculous." Then he went, "No, watch this," and put 60 up at a time and that suddenly makes a constellation of 12,000 quite achievable.

Melrose Brown:

Quite achievable.

Steven Henry:

And keeping in mind as well, that those are 200 kilogram satellites. You can imagine how many 10 or 20 or 100 kilogram satellites. The numbers are exponential. As the satellites get smaller, more and more of them could end up in space.

Michael Veitch:

Well, to that, guys, on where we are with satellite technology, because I suspect that's what a lot of our interaction with space is going to hinge. They used to be the size of one of those old 240 Series Volvos, but they're not anymore. They're much, more smaller. So physically, what would I be looking at with one of the smaller satellites if it was on a bench in front of me?

Steven Henry:

Well, I think this is where Melrose talks about the 'M2 Pathfinder'.

Melrose Brown:

Thank you, Steve.

Michael Veitch:

Melrose, please. The M2 Pathfinder. Over to you.

Melrose Brown:

Satellites come in all range of shapes and sizes.

Michael Veitch:

Let me show you our range, Sir.

Melrose Brown:

Here's one that we made earlier. Through a RAAF-funded program of research and education, our university group has been developing small cube satellite missions to demonstrate interesting technology. The latest one that we launched is called M2 Pathfinder. We launched that in June this year on New Zealand's Rocket Lab launch. So, just over the water is a very interesting company called Rocket Labs that have developed a new rocket motor for launching spacecraft.

So, that satellite is literally the size of a loaf of bread. It's called a '3U satellite'.

Michael Veitch:

Excuse me?

Melrose Brown:

Yeah.

Michael Veitch:

Can you just wind back on that one? The size of a loaf of bread?

Melrose Brown:

Yes, and that's a '3U'. They can go down to '1U'. A 'U' is defined as a 10 centimetre by 10 centimetre by 10 centimetre cube, and the idea behind these is that you can grow the form factor by multiplying your U's. Our 3U is about a foot long and about 10 centimetres square cross-section.

The important thing to realise, though, is that the smaller your satellite, you can cram a lot of interesting electronics in there, but you will never be able to replicate the capability of a several tonne communication satellite in one small system. But what these small systems can do is you can rapidly test and develop and prove out technologies. In our case, this is a Pathfinder for our main M2 mission that we'll launch next year. Those are bigger satellites that have got telescopes and radios and interesting science experiments focused on maritime surveillance and space situational awareness.

What we managed to do with this small one was very quickly in the space of 10 months is design, build, integrate, test, and then get it to the launch service provider. So, in 10 months you're able to test out all of these systems and prove that they're going to work before you go and do your bigger satellite.

Where these small satellites have a really interesting capability advantage is when you've got lots of them all working together, taking that role that your one really big, monolithic space asset would have and splitting it across a network of smaller satellites. So, talk about resilience in space. If you've got a network, and if one of them goes down, another one can take its job, then there's a lot of really interesting concepts that are coming down the line and I think in the next few years you will see a lot of really interesting uses for intelligent, networked, small space craft.

Michael Veitch:

And referencing my rather flippant intro to Conversations on the Runway today where I talk about the fusion between science fiction and science fact, what you just said sounds so much like that network of satellites. I have seen that replicated in stories in popular culture. It's obviously within the conceivable bounds of our space capabilities.

Melrose Brown:

It's really replicating what's happening in society anyway. So if you think of telephones for example, it used to be a very centralised system. Now we've got these little computers in our hands, and they do quite a lot. So all of that information about where we are, what we're seeing, you're taking photographs of things. Each phone itself isn't that clever. It isn't that powerful, but it communicates that information back, and using that information en masse with companies like Google and Facebook and whoever are able to paint a picture of what's going on on the ground in ways that were just not possible 20 years ago. So, it's really replicating that in space.

Michael Veitch:

I guess the whole worldwide web relies on millions of us sharing tiny little bits and pieces of information, and it all gets put together somewhere.

Melrose Brown:

Yes, very much so.

Michael Veitch:

You mentioned New Zealand there. I did not include New Zealand in my list of countries entering the space race if we're actually in one. Is that what's happened with the technology, gentlemen? Like, when our parents' generation bought a new television set in the 50s, it cost half my dad's yearly wage. Now you can buy them at the supermarket virtually for the cost of taking the family out for a meal. Has space technology gone the same way? Is that why people like India and ... we didn't even mention China, maybe that's for a whole other episode. But smaller countries are able to put Elon Musk's satellites into space, because it doesn't cost that much to do it anymore.

Steven Henry:

It's probably a combination of factors. I think space capability has reached a critical mass where it's becoming a genuine part of national infrastructure. When space launch facilities used to be the rare domain of huge superpowers that had limiting factors. Because New Zealand just happens to be, and South Australia also happens to be great places to launch if you want to do a polar launch for example, sort of launching in a generally southerly direction to orbit the earth over the poles. Whereas other locations, the closer to the equator you can get are perfect for geosynchronous orbits, because you're using that free energy of the spinning earth to get directly to your geosynchronous orbit. Well, not directly, but more directly to your geosynchronous orbit.

The fact that there is such a demand with that commercialisation has meant that it has opened up the opportunity for countries like New Zealand to say, "Hey, you know what? I want to get in on that market," and suddenly, "it's worthwhile for me to do so". So Rocket Lab went, "You know what? That sounds like a pretty good idea". They've put a small polar launch facility in New Zealand, and suddenly they're in the race, because they can be. And Australia will be soon enough as well. We've got some excellent launch facilities gaining a lot of traction here in Australia.

Michael Veitch:

We're going to talk about Australia's involvement separately in another episode, but that's good to know that we are in this race. What's happening over in South Australia?

Steven Henry:

South Australia has a company called Southern Launch looking at opening a facility in a place called Whalers Way. Of course, that's where the space agency is based. So, it's a good time to be a space company in South Australia. But

yeah, Southern Launch is the name of the company down there, and they're a very well progressed organisation. And Equatorial Launch Australia is opening up in the Northern Territory.

They're the two main facilities I know about. One accessing polar launch vectors and one accessing geosynchronous launch vectors. Vectors isn't the right word. What am I trying to get to there, Melrose?

Melrose Brown:

Orbits.

Steven Henry:

Yes, sorry. To get to those orbits, but the trajectory, sorry, is the...launch windows...their trajectories are suitable.

A lot of people talk about Woomera, for example. "We used to launch out of Woomera. Woomera is great." It's like, "Well, Woomera is actually pretty crap now," because it's not particularly close to the equator, and it's got to fly over populated areas to get to polar trajectories. So, it's actually not a very good launch facility at all.

Michael Veitch:

That's interesting. Just to that fusion of the military and private enterprise aspects of space, where's the money, gentlemen? Money makes the world go around. It makes space happen, too. What's the backend as they say in the film industry? What are the sources in space technology that people are filling their bank accounts?

Steven Henry:

Communications. Communications is by far the biggest at the moment. I think it makes up about 60%, or something like that, of space revenues right now, and communications includes a whole bunch of things like television services, satellite radio, actual communications using internet, and other data and voice services. So, by far the lion's share is in communications at the moment.

Launch is growing quite rapidly, as well as other services like Internet of Things. Being able to ... again, another Australian company, Fleet and Myriota are developing Internet of Things type capabilities where a vast country like Australia that has cows out in the middle of nowhere and farmers having to drive huge distances to check on the cows and the dam and the gates and all that sort of things can now possibly link all of these things up directly to satellite and back to a home base using Internet of Things capabilities. So again, a form of communications.

Michael Veitch:

I'm curious to know, does climate change down here have an effect on our atmosphere, which I assume it does, and then therefore on the lower Earth orbit and everything that’s actually using that lower Earth orbit like the International Space Station, etc?

Steven Henry:

The atmosphere is actually quite dynamic. It's not just there's a layer of earth, and there's a layer of atmosphere. It grows and shrinks and then changes in density and that sort of thing as various influences, including temperature and solar activity and that sort of thing change the shape of it. I don't think I would directly link that to climate change on earth. I would just say that it's dynamic, and it follows the 11 year solar cycle. It expands and contracts along with solar activity.

Melrose Brown:

Something we didn't really get into that much is the actual space environment itself. Typically, people think of space being this empty vacuum with nothing in there. It's an incredibly complex place that's filled with really complex space physics, and for us on Earth, a lot of that is driven by the sun. You've got the general radiation that's given off, but there's coronal mass ejections, there's solar flares, there's a solar wind. A whole bunch of really energetic particles that come towards Earth.

We're protected by the magnetic field that surrounds Earth, which means we're not getting totally smashed with radiation, but these high energy particles can find their way into Earth's atmosphere around the poles. That's where you get things like the Northern Lights.

So, as far as climate change affecting space, a lot of it is space affecting Earth. So what we're doing with climate change is that we're degrading Earth's ability to be able to protect itself from all of that radiation that's coming through. So, the hole in the ozone layer is a good example of that. Ozone's really good at soaking up lots of high energy particles, and you've got a big hole there. Yeah, you're going to get sunburned basically.

So, there is a feedback between what's happening terrestrially and what's happening in the upper atmosphere, but it is a really complex thing. Not so much climate change per se, but yeah, it's just a really complicated, highly dynamic, coupled environment.

Michael Veitch:

Last question around human security and climate security. In so far as Australia's Pacific Step-up program, we're looking to be good neighbours and as a middle power in our region, is there anything that we can do vis a vis our ambitions in the space frontier to help our Pacific neighbours align with us in our region?

Steven Henry:

I think so. A good example of where that could be done, and it's a nice nation building type activity is Australia's National Positioning Infrastructure Capability. Geoscience Australia is responsible for – augmenting, well they're responsible for a project that will augment GPS coverage in Australia. So their goal is to get GPS accuracy down to three centimetres within Wi-Fi coverage and 10 centimetres across the entire country, which is a pretty phenomenal capability. And it's an entirely civilian capability. Sorry, except for obviously the GPS part that the USAF drives, but the capability is available.

I see things like that that could provide genuine services and whatnot within our regional partner countries. Absolutely a way that we could help them better access and better use space services, some of which are already available. We're just getting them more on board.

Melrose Brown:

I think also the training and skills development as well. We're very much on an upward curve. How are we going to use this new space paradigm for our own uses? The US and other nations have a long heritage, and they're kind of tied and wedded to that, whereas in Australia we certainly have an opportunity to really embrace this new way of doing space and generating a more modern approach that works for us. We certainly have the skills and people and good will, I guess, to be able to bring other people in our neighbourhood along with the journey, too.

Michael Veitch:

To the crunch gentlemen, I want to ask you both this. Can you imagine a war being fought or even won in space?

Steven Henry:

I think space will absolutely be an element of whatever conflict we have in the future. That's quite unavoidable at this point, but there's a great analogy - if you can imagine - and this purely refers to kinetic-type capabilities. People think of conflict, they think of blowing stuff up, right?. It's not a useful way of thinking about conflict when it comes to space.

If you can imagine all of the bullets that were fired at Gallipoli, for example, continuing to trace their paths today or any explosion that occurred on earth just continuing to explode in that location for the next 1,000 years, people would think very, very differently about ever employing weapons. That's what happens in space. When you fire a weapon that destroys something in space, the remnants of that weapon and the explosion and the thing that you've destroyed are there for thousands of years moving at kilometres per second. So, they're all weapons, they're all destructive, and they're all destroying the space environment.

I think any future conflict involving space will predominantly be an electronic warfare-type activity influencing your ability to use those services to support your operations in other domains.

Melrose Brown:

Maybe to reframe your question, I can't imagine a war ever being fought solely in space. The only reason that we have anything in space is to achieve some kind of effect on ground. We don't just put things in space for the sake of it. We're trying to achieve some sort of outcome for either society or military or whatever.

So, if there's a war in space, there's very likely going to be a war somewhere a little bit closer to home. So it will certainly be involved in any conflict that we have, just what form that takes is perhaps a little open for debate at this time.

Michael Veitch:

It's been a march of folly in many military thinking that one particular technology alone can swing a battle. The RAF bombing offensive of Germany. The air offensive in the Kosovo War was thought to be something that could

win that battle alone. Proven not to be the case. Likewise in space, though, as with other military spheres, is it simply a story of capability being met with counter-capability at the moment?

Steven Henry:

Absolutely, and I guess as you really identify there, it's just part of a capability mix. It's a part of your overall national power along with every other element of your national power. There's diplomatic means and informational and economic. It's just another part of the mix, but importantly, it is another part of the mix that is quite distinctive from the other parts and absolutely requires its own form of consideration and policy and a share of strategy and that sort of thing as well. Just the same as a brilliant Naval Admiral wouldn't know how to run an air conflict or an air war or an air campaign, similarly space deserves its own professionals to get the job done in the best way possible.

Michael Veitch:

Melrose, is it going to be possible to govern space or govern in space. Are we anywhere near that?

Melrose Brown:

That's a really interesting question, and I think that will be teased out in a later episode, but certainly all of the rules and regulations that are basically international law were established back in the late 60s, that Cold War period. The feeling now is that we need to establish norms and guidelines and figure out how we're going to sustainably act in space so that we preserve that domain and that resource for generations to come.

But it seems that having hard and fast rules and regulations that everyone signs up to in a very legalistic way is unlikely. It needs to be - we need to have cooperation and collaboration across all users of space and really seek to agree on rules of the road and guidelines rather than enforceable laws.

In the commercial sector, I think the insurance piece will be a very important aspect as well. So, how much risk are they willing to take before they're going to insure your commercial satellite, could play really interesting commercial and financial push and pull on how people choose to act and behave in the space environment. So, certainly a very, very important aspect and one that's receiving a lot of attention from various international bodies, such as UN [indistinct] that are looking at developing these long-term sustainability guidelines, and a range of other bodies such as, there's Debris Mitigation and a range of different groups that are looking at what this might look like into the future.

Michael Veitch:

I wonder who will put up the first ad in space. The first commercial. It's going to happen at some stage. Maybe not within our lives, but there'll be ...

Steven Henry:

Not too far off. The idea was had, and I'm going to be pretty fuzzy on the details here, but to launch an asteroid shower over the Tokyo Olympics, I want to say.

Michael Veitch:

Get out. Are you serious?

Steven Henry:

Yeah, you know, next level fireworks. Fireworks from space. I'd have to Google it to get any details, but that was one thing that was thought of there.

But the point you made earlier about the preamble of the outer space treaty for all mankind or humankind as we would probably say these days. It's such a complex issue, because you see SpaceX, for example, putting up so many satellites. That could be seen as very much a land grab, for want of a better word, where they are dominating a certain part of earth orbit for commercial gain.

But if you consider the democratisation effects of having a global, truly accessible, anywhere internet, what that might do for humanity in terms of providing internet access to the young girl on the ground in, I don't know, pick a country, any African country, where they may not have the infrastructure. But suddenly they may be able to access it more easily without having to rely on huge amounts of national infrastructure. Just power and a small device that can access that internet. The democratisation for humanity is considerable. I'm not sure that Elon Musk's motivations are entirely humanitarian, but you can't deny the impact that global communications could have.

Michael Veitch:

Did you want to add to that, Melrose?

Melrose Brown:

I would just very much echo those sentiments. You know, OneWeb was another company that had a large constellation of satellites to provide internet everywhere, and once you can give people access to information easily, there's a lot of very good things about that, certainly on the education front. If you're talking about raising people out of poverty and really having a big impact, then education is absolutely key to achieving that. And that's the dream and the goal that we have. But what we're also seeing is that access to information from any sources has a less positive influence as well.

It's going to be interesting to see what the actual end outcome is from all of that. I have strong hopes that it will be very largely positive, and we'll get to see really good outcomes for everyone. But maybe I'm an idealist on that front.

Michael Veitch:

Well, I hope you are. Going forward, it's way beyond the capabilities of just government and just private enterprise. It has to be a fusion. Space will end up being the world's biggest private-public partnership, will it not?

Steven Henry:

Absolutely. I was trying to hit on that earlier when I said it becomes a part of our infrastructure. Governments build roads and hospitals and police stations and airports and all that sort of thing, and those are all obviously a mix of private-public partnerships and that sort of thing as well in some regards. The Australian Space Agency is obviously a huge step towards viewing space as a public case and a matter of public infrastructure here in Australia as well.

We've had very intelligent people working on space here for a very long time. But now as globally space increases in its importance and value and that sort of thing, suddenly the Australian government is realising the value to Australia in terms of employment and revenues and being a part of this huge global pie.

Michael Veitch:

Part of that global pie is China...I didn't even mention China, because I wanted to spend a bit more time on it. We'll have to do it in another episode, because I reckon that's a conversation all on its own.

I wanted to ask, though, just going back, because we are nearly out of time, gentlemen...it's been absolutely fascinating...is everything that we put up there still there? What about all the satellites that went up in 1973 and 1982 that have run out of juice? Are they still whizzing around up there?

Melrose Brown:

Well, it depends. In low earth orbit, if you're low enough, so around 600 kilometres altitude, there's enough atmosphere from Earth lying around that they will naturally decay. They'll come back to earth, and they'll burn up in Earth's atmosphere. So we've launched lots of things into LEO, and the standard way of doing things is, "Oh yeah, sooner or later they'll come back and we don't have to deal with those".

Once you go out very far away from Earth, so out to the geosynchronous belt, there isn't really any atmosphere there. They have a graveyard parking orbit. Once your very important GEO slot, the satellite there has reached the end of life, it's got a bit of fuel left, and it'll boost out to a distance away from the GEO belt into this graveyard orbit. It's really a dumping ground...

Michael Veitch:

Graveyard orbit?

Melrose Brown:

Yes.

Michael Veitch:

Wow.

Melrose Brown:

Yes, so kind of like how the elephants have their elephant graveyards, we have them for very large, very expensive satellites in space. We cannot keep doing that, though, because sooner or later there's going to be too many things in there, and they'll start hitting each other and bad things can happen.

Michael Veitch:

Well, Sandra Bullock and George Clooney in ‘Gravity’. I probably should have mentioned that movie at the top end of the show where that's what happens. A satellite gets smashed into by another piece of space junk, and they're in deep, deep trouble. Is it like that? I mean if an astronaut accidentally let go of a spanner in 1970 or 1980 during the Shuttle program, is that spanner out there traveling at 30,000 miles an hour around the Earth?

Melrose Brown:

The spanner will have de-orbited, because the space station's really low. But if you go a bit further up, then yes, that debris will remain there. So a spanner's relatively large, and you'd probably be able to track that.

You think about a ball bearing or a bolt, so a very small bolt, that's traveling at eight kilometres per second. Whatever that is in kilometres per hour. It's like 28,000 kilometres per hour. Someone will have to check my math, so I'll leave that as an activity for...

Michael Veitch:

A bullet effectively. A bullet.

Melrose Brown:

Well faster than a bullet.

Steven Henry:

Much, much faster than a bullet.

Melrose Brown:

Much, much faster. If something the size of a bolt hits a satellite, and it's got a bit of mass to it like a bolt does, then it is going straight through that satellite and yeah, it will shred whatever it hits if it hits it at those sorts of velocities. So, having big bits of junk isn't nearly as much of a problem as having little bits of junk. The thing is, once things start crashing into each other, big bits become small bits quite quickly, and then you're chasing your tail a bit.

So certainly, how to deal with the debris population or the potential debris population and really doing our best to limit the amount of junk that we create is a really important thing that we need to be focused on.

Michael Veitch:

And just a teaser for a future episode. We will be having a chat to Alice Gorman, Dr. Space Junk, from the University of South Australia. She's a fabulous person to talk to on this subject, as have you gentlemen been.

I've got to ask you...Star Trek, Star Wars? What camp did you fall into as youngsters? Melrose, over to you.

Melrose Brown:

I'm going to lose my job here.

Michael Veitch:

You're going to be a party pooper. You're a party pooper. Go on.

Melrose Brown:

I've watched them, but I was never a massive, massive fan to be honest. So, this is going to go live. It's going to get back to my colleagues, and I'm going to get run out of town for this, but I was a bit more of a Star Wars fan. But I was not nearly as fanatical as you are. So yeah, you've just ended my career. Thank you. Thank you for that question.

Michael Veitch:

Steve, fess up.

Steven Henry:

Star Wars all the way, but as a space professional I wouldn't be doing my job if I was going to say please don't watch any sci-fi if you want to learn about space.

Michael Veitch:

And I've had the experience - of watching a hospital TV show with a doctor. All they do is, she just whinged and complained, said, "That's not how it happens, that's complete nonsense." So, please don't take any of your partners, spouses, children to Star Wars. They will not enjoy the experience.

I'd like to thank our guests talking about space today. Boss of the RAAF's Surveillance and Control Training Unit, Wing Commander Steve Henry, and from the University of New South Wales, Dr. Melrose Brown who heads up the Space Masters Program, which I bet is very similar to the Jedi Masters program. Melrose, is that correct?

Melrose Brown:

Exactly. I can't talk about it.

Michael Veitch:

Thought so, thought so.

Gentlemen, great to talk to you. Steve, I'm just hoping that when I talk to you next week, there will be a question, the answer to which will be something like, "I'm sorry, Michael. I'm not at liberty to talk about that." Do you think that's likely to happen?

Steven Henry:

Sorry, Michael. I'm not at liberty to talk about that at the moment.

Michael Veitch:

That'll do it for me. Thank you, gentlemen. This has been Conversations on the Runway. We'll see you next time.

Steven Henry:

Cheers, Michael. Thank you.

Melrose Brown:

Thank you.
