



ROYAL AUSTRALIAN AIR FORCE

Podcast Transcript

Conversations on The Runway – Space Series Episode 5 – ‘*Space Archaeology and Sociology*’

Host: Michael Veitch

Guests: Assoc. Prof Alice Gorman, Dr Evie Kendal, Annie Handmer

Michael Veitch

Now, I know I started this space series of *Conversations on The Runway* by going on about Star Trek and Star Wars. And how it's through this sort of space related popular culture we've developed a perception of what it might be like to actually live and work in space, which, let's face it, isn't the most original observation. It's a bit lazy really, some might say cliché. So, this week, I thought I'd do it again.

Lost in Space, yes, you remember the TV show made in the '60s about the Robinson family, Dr. Smith, the robot, “Danger, Will Robinson”. Yes, all that sort of thing which basically transposed White American middle-class family values into outer space via their very elegant, rather sexy, silver flying saucer, the Jupiter 2.

Actually, it's just been remade, and it's not bad. But it's essentially the same thing now except the mother character actually has a couple of degrees, and is allowed to do stuff besides making dinner and getting in everybody's way and whining about being a good mother, and a wife, blah, blah, blah. So, in the new one, Molly Parker at least fires a ray gun a few times, and Dr. Smith is a woman which is actually pretty cool. But Lost in Space for all its yawning faults at least attempted to relay the idea of people living in space permanently as opposed to just being on a mission to go up there and blow something up and come back again. The Robins, Will, Penny, and the Robot were up there full time. And as a kid, it did make me think about what it would be like to live in space, and all the practicalities, which when you think about them, are absolutely endless.

Now, this was after all, at the height of the Apollo Space Program. But to be fair, such speculation goes way, way back before the 1960s. But when do you think Lost in Space was set like when the story was supposed to happen? In the far off distant future hundreds of years from now perhaps? Well, when in 1965 the Robinson's Outer Space saga first blasted off the launch pad and onto our afternoon television sets. The story was set in that far off distant year of... wait for it, 1997. For centuries, mankind has fantasized about the idea of living off planet. But today, it's never been more technically possible.

On *Conversations on The Runway* this week, we've been thinking about life in space for ages. How much have we learned in the 60 years we've actually been up there? Oh, and what happened to all the stuff we've left in space. Apollo 11 alone left 106 separate objects on the moon, messy buggers astronauts. We'll be delving a bit into space archaeology too. I will in advance beg the forgiveness of our three wonderful guests today because if I were to mention all their brilliant achievements, positions, and qualifications, we'd not have time for anything else.

Dr Evie Kendal is a bioethicist and public health researcher at the Department of Health Science and Biostatistics - that's hard to say - Swinburne University of Technology. Evie's research

interests include ethical dilemmas in emerging biotechnologies, space ethics, and public health ethics, and is currently working on the ethics of, get this, the use of artificial wombs on other planets. Don't think we won't be getting to that a little bit later.

She's joined by Assoc. Prof Alice Gorman, from Flinders University in Adelaide. Assoc. Prof Alice Gorman is on the advisory council on the Space Industry Association of Australia as well as in the UN Office of Outer Space Affairs. Wow. And an author who occasionally goes by the moniker, Dr. Space Junk - because Assoc. Prof Alice Gorman has written some of the best space reads you can get your hands on, particularly *Dr Space Junk vs The Universe*. It is a great read. I've read it.

And please welcome back any Annie Handmer from the University of Sydney, who is on the advisory council of the Space Industry Association of Australia, helps put together the brilliant space exhibit at Questacon in Canberra, and is the host of the very cool Space Junk Podcast. And my spies tell me Annie is also an opera singer. Annie, you know it's going to happen one day. What will be the first opera performed in space?

Annie Handmer

Well, you'd think that *Einstein on the Beach* might be appropriate.

Michael Veitch

Well, let's contemplate that a little bit later. Alice Gorman, do we need to simply evolve further as a species before we can even contemplate living in space?

Assoc. Prof Alice Gorman

Well, I think that's such an interesting question because we can take evolution on a couple of levels here. And as an archaeologist, my former interests used to be looking at how humans had evolved physically and culturally over deep time, over millions of years. And we've basically evolved in this really little narrow strip where there's a certain atmospheric pressure, where we have access to water, where we have consistent earth gravity for everything that we do. That gravity is the backdrop to every social and technological and cultural form that humans have adopted. But of course, when we go out into space, that's all completely different. That consistent factor of gravity is taken away.

Michael Veitch

It's like a whole planet itself is in a 'Goldilocks Zone', as I call it. But we as a species live in this little band on this planet that is in itself a Goldilocks Zone within a Goldilocks Zone, isn't it?

Assoc. Prof Alice Gorman

Yes, it's a little beautiful bowl of lukewarm porridge that won't burn our tongue. And to go into space and live in space, then there's two ways we might evolve or adapt. And one, of course, is physical evolution. Our bodies simply aren't very good at being in different kinds of gravity. But I think the other big aspect to this is social evolution. So, one of the major concerns that there is for the crew on the International Space Station (ISS), and for all of the previous Soviet, Russian and US space stations, and the prospect of habitats on Mars and the moon, is how are people going to get on with each other? And we're not actually very, I don't know... there's that whole concept of the evolution of our social life where we can't even take it for granted that people will be nice to each other. So, how are we going to tackle that in space?

Michael Veitch

I want to get on to some of the fascinating machinations of the ISS a little bit later. But Evie, what's your take on our evolutionary state at the moment? And are we ready to do something, so extraordinary, as even contemplate any kind of human activity in space on a larger scale than what we know today?

Dr Evie Kendal

Well, it's very interesting because as you mentioned, of course, the Goldilocks zone, we have evolved for life on this planet. And even then, there are some improvements that we could make in terms of our resilience. I'm thinking of things like our resilience to UV. I mean, even on this planet, we still have things like skin cancer occurring. Now, of course, if we take it to space, we are not adapted for that environment at all. So things like cosmic radiation, obviously very problematic for human bodies. So, we've got this issue where we've evolved naturally to a relatively good space on earth. I mean, as I said, there could be some improvements. And one of those in my view is, of course, developing technology to take over some biological functions.

But when we're looking at how we might evolve for space, you could argue that we've evolved on earth to the point where we have the technological knowledge to direct our own evolution for more appropriate space travel, resilience, etc. So what we're thinking about there is, of course, are we able to genetically modify ourselves so that we could be more resilient when it comes to things like radiation and avoiding things like cancer in space? So, you could argue that evolution has taken its natural turn up to a certain point, and that we have in that time developed the knowledge, intelligence, in order to then augment ourselves in other ways.

Michael Veitch

Wow, that really is nudging into... I started talking about science fiction, but that is really nudging into it in real life. That's extraordinary. But these highly evolved people, the space community, can either of you speak to what the people in the space community around the world are like? I mean, are they a more highly evolved species than the rest of us? And I include you two in that as well. What motivates... I mean, seriously, what actually motivates people to work in space apart from the fascination and the glamour? Are there higher ethics and morals at work there with the people that you've come across?

Assoc. Prof Alice Gorman

Oh Michael, I think you know the answer to that question. The space community is like every other community on earth. It's by no means smarter, or more evolved, or more ethical than any other community on earth. And I think that...

Michael Veitch

But it has to be, surely. Surely, it needs to be going forward.

Assoc. Prof Alice Gorman

I think that's why it's actually really important to have people like Evie and I thinking about these issues, because we're both part of the space community, but we're also kind of a little bit to one side, I guess, because we come from... We're not engineers, we're not physicists. So, it's really important, I think, that we get a multitude of perspectives.

Michael Veitch

Well, looking at both your educational paths. We've been discovering on the Space Series of '*Conversations on The Runway*' that so many people who participate in the space community, the space industry, what have you, have these incredibly eclectic, wide ranging educational backgrounds. It's a...a layman like myself would assume everybody is a physicist, everybody is an engineer. And that's all you need, but not so. I mean, if we are looking at putting humans up there, we have to embrace all of humanity, and all of human experience. That's a comment more than a question, but you're very welcome to jump in.

Dr Evie Kendal

Well, it's interesting because you're asking about the space community, and of course, it's not homogenous. So, you do have all that diversity, the same as in every other sort of community. I can speak from personal experience being relatively new to the area, that people are very supportive, and they're very friendly, and they're very happy to share their knowledge, which has been a really good experience. It's not always the experience in academia.

Michael Veitch

We've been contemplating space for much longer, of course, than *Lost in Space* and the '60s. And we were talking the other day, Assoc. Prof Alice Gorman, you told me of a wonderful old book penned long ago titled '*Brick Moon*', which has some wonderfully prescient visions of what humans in space might be doing. Tell us about *Brick Moon*.

Assoc. Prof Alice Gorman

It's an amazing book. So it was written in 1870. And there's a whole bunch of things that were going on in it. So, the author had figured out that you could use satellites to help navigation for ships on the ocean. Because potentially, you could build a very, very tall, tall, tall sort of beacon, but to be tall enough to go to work over larger distances, you wouldn't physically be able to build it on earth. So he just extrapolated and said, "Okay, we'll make this little beacon be in earth's orbit. So, one of the earliest satellites conceived was actually the precursor of our current navigation satellites. But what they did was, and this is super smart, he proposed to build it out of bricks because bricks are clay that has already been fired. So, in order to get into space, and be subjected to much greater heat than you would get on earth, bricks would be a very resilient material, and would also be good insulation. So...

Michael Veitch

Hang on, hang on, was not the space shuttles covered with ceramic tiles?

Assoc. Prof Alice Gorman

This is true. Ceramics are an amazing space material. And when we think ceramics in space, it's not just things like our tea cups. These are often highly complex materials that are bonded with a whole range of other materials to create properties that allow them to survive. As Evie said, radiation is a big one, and temperatures are another big one. So, what's amazing to me is that bricks in the *Brick Moon* are the precursor of this. So, what happens is they build it like a sort of beehive. It's kind of got little cells inside and people can go into the little cells. So, look, we're talking in the 1870s some pretty advanced space architecture here.

Michael Veitch

I'm guessing that was perhaps an era where there was a sudden going along with this sudden industrial developments. Were new telescopes coming online at that stage or something like that? Because I know that there was a flurry, you know, Jules Verne and H.G. Wells; a flurry of sudden interest in how we look at space. And it was the first sense that one day around that time, the first sense that one day man might be able to get there, historically speaking.

Assoc. Prof Alice Gorman

I think you're spot on with that connection with industrialization and globalization as it was in the... well, from about the 1700s, 1800s, 1900s, you're getting a sense of the world as something that you can circumnavigate, you can go around. Jules Verne Around the World in Eighty Days. It was effectively an orbit, but just very, very low on the surface of the earth. So, the Brick Moon is starting to think of space as part of that economy. So, it's very early kind of expression of drawing off earth places into the operation of terrestrial markets and commercial activity.

Michael Veitch

I wonder if young people who are interested in space are still reading things like Brick Moon and H.G. Wells. But today we do have dedicated organizations, Assoc. Prof Alice Gorman, things like the Space Generation Advisory Council. We want to get young Australians interested in space. Are they and are organizations such as that the right way to go? Are we catering for this burgeoning interest of young people to hit in that direction?

Assoc. Prof Alice Gorman

Well, I've got a strong opinion about this, and I think one of the most critical ways that we can get young Australian people interested in space is to give them more information and more access to Australia's amazing space history. All of the incredible things that we did. People think the space agency, which was formed in 2018 was the start of Australian space. But we've been there the whole time...

Michael Veitch

No, no, no.

Assoc. Prof Alice Gorman

... the whole time. And I think it's quite inspirational to think of Woomera, Australis OSCAR 5, WRESAT 1, Honeysuckle Creek, so many places and stories of what Australians did in space.

Michael Veitch

We were looking at... In a previous episode, we were looking simply at Australians in space. And yes, the history goes way back to Woomera. The Dish, of course, the boys and girls I used to work with in that lovely film that gave so much a consciousness to some of our space history relating to the Apollo missions. But we'd love to think that we can still be in it going forward. I mean, if other nations can have a space program: India, Canada, China, of course, plus the other big ones. Surely, there's room for a smaller middle place like Australia. With all our wonderful natural resources in our space. Vastly, sort of areas where there are no population. We're a lay down misere for 50, 60 years for a decent space industry, wouldn't you think?

Dr Evie Kendal

Well, I think absolutely. And I think it's a good point to be entering as well in that more practical sense because we've established a community that does collaborate internationally very well. And it's not like we're starting with nothing. As we've heard, we already have quite an established history. We have collaborated extensively in this area. And now we're sort of carving out our own space as well. And my personal agenda is, of course, that Australia be at the forefront of developing things like space law and ethics as a particular area of interest moving forward.

Assoc. Prof Alice Gorman

I want to absolutely echo that, actually. So, I think we can't compete... I mean, we're doing pretty well. We've got rockets launching, being built. We've got satellites going up. But we can't really compete with those big space powers. But work like what Evie is doing around space ethics is truly original and unique. And I completely agree, Evie, I think Australia can make a very significant contribution in some of these specialist areas.

Michael Veitch

Evie, I want to ask you about those ethics. What makes space ethics different to other sorts of ethics?

Dr Evie Kendal

Well, on the one hand, I want to say nothing. Because of course, a lot of what we're doing is extrapolating from ethical dilemmas on earth and seeing what they would be like in space, but there are some unique elements that make space ethics really fun to work in. And that's things like that level of international collaboration. We don't see that in other areas of research and other political agendas. So we do actually have a very special area there.

We also have a lot of different views about space. When you compare them to how people view similar things on earth, you do see a lot of contradiction. So, people can be very protective of the space environment and not wanting to harm any potential life signs or bio signatures. But then on earth, we have so much environmental degradation, so many species going extinct. And the disconnect there is actually fascinating in its own right. So, we're looking at the ethical treatment of other spaces and histories and worlds, we're looking at potential rights for species that might evolve in the future. And then we compare it to the treatment of our own planet. That is where some really juicy work is done.

Michael Veitch

You've spent a lot of time drilling down into the precise practicalities, and they're fascinating of what human society would look like out there - even down to questions of fertility in space. And of course, we need to contemplate these sorts of things. If we're thinking of living up there, we must think of what human reproductive systems would look like. Have there been studies into the effects of things like microgravity into fertility, and particularly the female anatomy and what are we discovering? Or perhaps there's been not enough information coming to us from that field?

Dr Evie Kendal

We definitely need more information. So, we do have studies. We have computer models. We have animal studies, that kind of thing. And of course, we are trying to extrapolate from other conditions where we have seen the impact of extreme environments on things like pregnancy and reproductive sort of functions, particularly for women. But what we don't have is an example of someone being pregnant and giving birth off planet. So the reality is, we really don't know what's going to happen there. We have to wait and see. Eventually, we're going to be living in space, which means people will be having sex in space, which means eventually someone's going to get pregnant. So, we know that's the future, if we're going to have settlements off planet, that's definitely something that we need to look to.

Michael Veitch

Someone that had to say those three words in sequence because they do roll off the tongue, don't they?

Dr Evie Kendal

Indeed. Indeed, they do. But we can extrapolate from known risk factors to adults. We know that, of course, there's a risk for burned mineralization. We've got muscle wasting. All of these things can occur to adults in space, and we would assume there would be similar impacts, perhaps even more substantial risk factors for children. And then of course, we'd have to try and work it back to fetuses as well and see what happens there. But again, we don't know what's going to happen with our first sort of microgravity pregnancy. So, we can do more studies on animals. We can do more computer modelling, but eventually it's going to come down to actually observing it in practice.

Michael Veitch

Has there been any kind of resistance or indeed a taboo in exploring these sorts of questions within the space industry?

Dr Evie Kendal

Well, yes, if we remember, people used to be concerned about female astronauts at all because what about all those biological functions that we don't want to deal with that are somehow so different to all the other biological functions that all the other astronauts were already dealing with? So, yes, there is absolutely antagonism toward pregnancy in space, and also basically just women in space. And it's quite interesting, because, of course, if we want to have settlements in space, those are our options. Essentially, we can't be moving everyone from earth. That's not sustainable. But eventually, we're going to be looking at either biological gestation in space or artificial gestation.

Michael Veitch

This goes back to something I read once, the advent of the motorcar in the early 20th century when some people said that women will never be able to ride in a motorcar because simply the speed of going at 20 miles an hour will disintegrate their beautiful, soft, delicate bodies. That female anatomy will simply fall to pieces.

Dr Evie Kendal

Absolutely, can confirm, totally happened.

Assoc. Prof Alice Gorman

It was the same for aeroplanes as well. Once women became expert drivers, then the next thing was acceleration in airplanes would dissolve their internal organs. And then the next thing was, they would be unable to withstand the rigors of launch when you've got an even higher acceleration. So, it was always this worry that somehow these female bodies that are used to being pregnant and giving birth and undergoing the most incredible stresses that completely change them, just would somehow just dissolve if they were subjected to high G-forces.

Michael Veitch

That's the physical though, of the effect of space on people living up there on long periods of time. To the psychological, though, and I read in one of the papers that you've written, Alice, that active space agencies with human missions have explicitly barred social science researchers from participating in space cruise. Why on earth is that the case?

Assoc. Prof Alice Gorman

I have to say, I really don't know. But NASA in 2015, and again, in 2020, they put out a call for people to apply to be astronauts, and they listed the kinds of degrees or education they thought would be useful. And they said explicitly that they do not want anthropologists, archaeologists, geographers, sociologists. And this actually...

Michael Veitch

It seems so counterintuitive, doesn't it?

Assoc. Prof Alice Gorman

It really does. Because there is so much concern about the social living conditions of these very confined and remote spaces. And you would think that somebody with skills in observing and documenting human behaviour might come in handy.

Michael Veitch

The moon is likely to be the first and perhaps only possibility, I would have thought, of a planetary body that may one day be utilized by our species. Let's talk to the ethics of that. Is it not there for it simply to be exploited? What are the ethics of colonizing the moon? I will throw that one wide open.

Dr Evie Kendal

Oh, no, we can't be exploiting it. I don't like that word at all. So, our issue there, of course, is are we able to use it in any way. Are we able to share it effectively across relevant stakeholders, but definitely not exploiting it. And of course, the issue we have there is what do we call exploitation? Is mining exploiting the resources? Is settling on that space exploiting a natural habitat? Of course, we have experts here that will be able to go into more detail there. But for my interest, of course, I think there is something very special about the moon that we need to be preserving in terms of its physical sort of space, but also its history and what it means to us as a species.

Michael Veitch

Alice?

Assoc. Prof Alice Gorman

Yeah, like Evie, and I should preface this by saying I've worked extensively in mining industry. So I've been a cultural heritage consultant working for coal mines, uranium mines, copper mines, across different parts of Australia. I actually do find mining technology quite fascinating. And I generally love learning more about it, and the downside of that is you're often on country with traditional owners immediately before it's about to be completely destroyed. So, when I think about mining on the moon, effectively, we're using a similar model. There's the idea that there's this resource there that is open for all humans to use under the terms of the space treaties that we have. But there's only a limited number of people who have the capacity or capability to actually get there and exploit those resources.

But this isn't like mining on earth, where you could argue that the very, sort of, late emergence of nation states as a political entity control the land within them, and the impacts of the mine are only on the people in that country, usually. When we're talking about the moon, everybody is a stakeholder. The entire population of earth is a stakeholder in what happens to the moon. And at this point in time, the private corporations, and the nations who are planning to go to the moon to extract resources. And I suppose I should qualify at this point in time that extraction is aimed at supporting lunar habitats or occupation in lunar orbit. It's not to flood back to terrestrial markets. But that could be something that happens.

Michael Veitch

Is there an actual push for this?

Assoc. Prof Alice Gorman

Oh, yeah.

Michael Veitch

Or is it in the realms of science fiction?

Assoc. Prof Alice Gorman

No, no, no. People are, and interestingly, I find this particularly interesting. Australia's role in future lunar or asteroid mining is being touted to be automation because we are very good at remote area automated resource extraction. So, that's what our role is meant to be in future of earth mining. The only problem with that is in different planetary environments machines don't operate in the same way that they do on earth. And on the moon, we have a major dust problem. So for people who are not mad or thrilled about the idea that we're going to start ripping minerals out of the moon, while we do have some parts of the technology worked out, there are other parts that we are absolutely nowhere near solving. So, this stuff is not going to happen in the next five years, maybe not even in the next 10 years, which is a little bit of a consolation.

Michael Veitch

Surely, I would have thought the biggest... As a layman, the biggest thing would have been air, creating oxygen, making oxygen. But you can't make oxygen, can't you?

Assoc. Prof Alice Gorman

You can make oxygen. But what people are going to do, the current target for lunar mining is water ice frozen at the lunar South Pole. And so, that will provide oxygen and water and can be actually used as a fuel source to maybe push on to Mars. So, everybody is aiming towards these ice field craters at the moment.

Michael Veitch

Back to human, actual, the way we live, and the way we might live up there. It seems to me the only template we have at the moment of humanity living in space is the ISS. I want to talk about the ISS a little bit. Though, is it likely that the ISS is going to yield anything useful about what space society in reality might look like, Annie?

Annie Handmer

Well, I just wanted to bring that back to what we were talking about with the moon just before and say that, one of the things the ISS has shown us is that we're able to be creative in space. We're able to work together in space and be collaborative in space. And I find it quite fascinating that even with that rich legacy there, when we think about going back to the moon, the first thing we think about is mining. It's like we can go to this rock, so let's chop it up into bits and sell it to each other. And that's where we are sending our structures. That's where we're directing our technologies. That's how we're setting up our financial systems.

Now, obviously, in sociology, we like to look at how individuals think about things and operate in things. But those individuals often create structures and those structures in turn have some sort of deterministic effect in that they are socially constructed, but therefore they push humanity towards certain things. And in the case of the moon we've forgotten all of the times that we've had fun on the ISS. That we've done collaborations on the ISS. We've done art, we've done music, and no one is now talking about, wouldn't it be nice just to go to the moon, and have a look around? Maybe do some bouldering on some of those big rocks. Maybe dip into a crater and see what's there.

We're already setting up the structures to begin chopping it up and selling it. And I think that's just something to take note of. And when we start talking about the moon and mining the moon, and exploiting the moon, to just note that that is a choice, it isn't the only option. And that we can always step back and say, "Well, hang on. Why? Why are we doing this? Do we need to be doing this? Can we just wait a little while and see what else the moon might offer? Or indeed, we might offer the moon." Absolutely.

Michael Veitch

I can see the first reality TV show being directly from the moon, Big Brother, writ large.

Annie Handmer

That lunar edition.

Dr Evie Kendal

No, the bachelor lunar edition.

Michael Veitch

Lunar edition. I'm fascinated by simply the scale of the ISS. I must confess to being one of those strange people that actually have the app on their phone to track it going over your house, and I quite like on a clear night watching the little white light going over. But the scale of it, it's described, it's the scale of a five bedroom house, 1000 square meters. The footprint, I'm told is the size of a US football field, whatever that is. It's had 239 visitors from 19 countries, but to note 16% of those have been women. 10 years life though it's got at the most. Is that true? Because what happens afterwards, then?

Assoc. Prof Alice Gorman

It's interesting, isn't it? So, there's two plans. It was always going to be deorbited much like the Mir Space Station was in 2007. I mean, it costs so much to run it, to keep it up there. And as Annie said, it's this example of international cooperation, which maybe we need in front of us to think about how we're going to use the moon. But what NASA is doing at the moment is opening it up for more commercialization. So, Estee Lauder, are supposedly to go in to film an advertisement on the International Space Station.

Michael Veitch

No. I see, I thought projections on the sales of the Sydney Opera House were bad enough, but this sort of takes the cake, doesn't it?

Assoc. Prof Alice Gorman

And I think this is interesting too because that commercialized model is a trajectory which is coming to dominate how we think of space resources. So, Annie was making a point, we should be looking to other aspects of this. Perhaps, it doesn't always have to be this one. But at the moment, the fate of the International Space Station is kind of up in the air. So, I suspect if there's enough commercial interest, and it's not as if companies don't pay for experiments and work to be done as it is. But we're talking about a much more aggressive model where a company might entirely fund one astronaut to work on some commercial product for them. So, unless that takes off, as far as I'm aware plans for eventual de-orbit are still on the table. And they have been preparing for this too. So, there have been some specific re-entry missions to model how you might break the station up and make it come back in safely. So, it's an interesting thought.

For 20 years, we have become used to this little capsule of humans floating above our head and little kids on Christmas Eve, they go out where it's visible, because now it's Father Christmas' sleigh. The International Space Station has become so entangled in our culture. If it isn't there, then the only space habitats we're going to have will be national ones. And that's a very different feel, I think.

Michael Veitch

Did you, I believe, get to examine some of the cargo coming back from the ISS, the human cargo? And I believe you notice the smell of humanity exuding from what was brought back up there. Is that true?

Assoc. Prof Alice Gorman

This was my colleague Justin Walsh from Chapman University who I'm working with on the International Space Station Archaeological Project.

Michael Veitch

I apologize.

Assoc. Prof Alice Gorman

And there's a couple of interesting things about this. One is that when you're excavating an archaeological site from the deep past for certain kinds of place in the Middle East and Europe, when you start to excavate down the layers and you get close to the layer where people were living, it starts to smell. So, even buried under layers and layers of dirt, there's a very good distinctive smell to occupation layers. Now, the International Space Station is very, very stinky, in general. So, they can't have showers. They have to wear the same underwear for weeks at a time. Apparently, it is just a very smelly place, and the stuff that comes back... So when Justin went to observe the unloading of the cargo, which took place at Long Beach. This was a SpaceX managed mission. The cargo handlers have a very complex job. The smell of space, the smell of that, the interior of the ISS with all of those bodies was still on the objects when they came back. And it was a very distinctive smell. So, space is a sensory experience as well as a psychological experience.

Michael Veitch

I would suspect that every astronaut up there is monitored 24/7, photographed, there are probably millions of photographs and images of human interaction up there. Can anyone talk to... are we learning anything from this in the long term about what society might be like couped up there? Highly intelligent, highly motivated, highly skilled people, but how do they get on? And I believe that there was one incident where the Russians wouldn't let the Americans use their play equipment.

Assoc. Prof Alice Gorman

Actually, I got that the wrong way around. It was the Americans who wouldn't let the Russians use their exercise equipment, and their toilets as well. So, because, as Evie mentioned, you have the bone density is lost very rapidly in space. So, they have to exercise for a minimum two hours every day just to keep their bodies healthy enough to return to earth and function. So, exercise is super important. But this isn't about efficiency, because if the space station had been designed to make the crew comfortable and happy, and hence work better, it wouldn't be the way it is now. So, the Russians were denied use - this is back in 2009 - were denied use not only of the US exercise equipment meaning they had to queue up and spend more time scheduling their access to the Russian exercise equipment, but they were also denied access. So, every nation had to use its own toilets. They couldn't share toilets. So, I think the interesting thing there is, what is the psychological effect of saying, "Well, we're not sharing anymore, everybody has to be separate"?

Michael Veitch

Evie, that would be something like a danger sign sort of sociologically speaking, wouldn't it? I mean, if we can't get on, well, in something like the ISS, what hope is there for going forward to actually having something more substantial?

Dr Evie Kendal

Well, yes, I can see how it would be a little bit distressing to think that we can't even manage to get past our nation state barriers to share a toilet in space. I mean, I get that might be a bit depressing. But we have to think about it, how poorly we get along across nation states on earth at the moment. And the fact that we still have this International Space Station. It is still functioning, and your question of, are we learning anything? Absolutely. I mean, not just about the psychological effects of being isolated, very extreme isolation, but also being cramped up with people that you didn't necessarily choose, that you don't necessarily have a lot in common with otherwise. These are things that, obviously, are very stressful. And we do learn a lot about how humans survive in that stressful environment.

We have evaluations of psychological wellbeing for people who are involved in that situation. So, we are learning quite a lot there. We're also doing medical research though and learning about things like could we potentially construct organs for transplant using 3D printers in microgravity? Because one of the problems we have with developing organs on earth through 3D printing is the models tend to collapse on themselves. But if we were to develop them, say in zero-G, we could actually hold them together in different ways such that we could develop them before they collapse in. So, that's a potential area of research. Obviously, it's very fledgling at this point. So, fingers crossed, but there's a lot of things that we are learning from this kind of research.

Michael Veitch

Not just organs, Evie, but you're working on the ethics of the use of an artificial womb in space.

Dr Evie Kendal

Yes. If we want to have...

Michael Veitch

You must speak to that.

Dr Evie Kendal

Yeah, if we want to have settlements in space, of course, we're going to need people and it won't be practical to take them all from earth. So, eventually, we will want to be engaging in procreation in space. And if it's determined that it's very unsafe for women to be pregnant in space, or it's particularly unsafe for foetuses to develop in that situation, then yes, we'd be looking at an artificial alternative. So, I'm in favour of developing artificial wombs or exogenesis, as it's known on earth, but of course, also for its application for space exploration. So, imagine transporting lots of embryos in your spaceship and then gestating them at the other end in a tank, for example. It's a lot simpler. It would also mean that we had a lot more flexibility when it came to the crews that we put on these spaceships to start with. So, the gender balance wouldn't be as big an issue. And of course, there are benefits to artificial wombs on earth that are also translated to the space environment. For example, gay couples could have genetic offspring without using surrogates. We can have a variety of other options. Women who don't have a uterus, they may have lost it to cancer or being born without one. Of course, we have transgender women who don't have a uterus who might want to gestate artificially, and all of these benefits for earth are also relevant in a space settlement.

Michael Veitch

We are coming to the end of it. And I know it's criminal raising this issue so late in the piece, but I do want to address briefly some of the detritus we have left up there. Annie, I know this is one of your specialties. Just give us a picture for the people who don't know, because it's extraordinary. How much stuff have we left up there in the 60 years we've been exploring space?

Annie Handmer

Well, it depends a little bit who you ask, because there are some objects in space that are tracked, but may not necessarily be reported. Various people have different registers. But the usual number you hear is 500,000 pieces, according to NASA. Or I've also had 650,000 banded around, but I'm actually going to defer on this to Alice Gorman who is the Dr. Space Junk to talk about this one in more depth.

Assoc. Prof Alice Gorman

I am going to use a different form of measure to describe how much stuff is up there. So, I recently calculated, by weight, how many cane toads worth of space junk were in orbit around the earth. And the updated answer to this is 10 million cane toads worth of space junk in space. If you think of the average size of a cane toad.

Michael Veitch

Well, I'm often thinking of the average size of a cane toad...

Dr Evie Kendal

Same.

Michael Veitch

I lie awake at night thinking, oh, are they getting bigger or smaller.

Assoc. Prof Alice Gorman

Well, we don't want them to get bigger. And I think that comes to the heart of the issue both on earth and in space.

Michael Veitch

And of course, this is going to be a huge issue if we go up there. I mean, I like to bring up science fiction again. But the film Gravity, I love the idea. The thing I like... The first thing I like about the film Gravity is that it was quiet up there. You couldn't actually hear anything, which is of course what it would be like. But I mean, a spanner or a bolt traveling at what speed...What would the impact speed be?

Assoc. Prof Alice Gorman

Well, in low earth orbit, it's an average of seven to eight kilometres a second. So, that is very, very fast. But both objects are traveling. So, if you remember your high school physics and vectors and stuff - so you combine two high speeds that collide. And even a little tiny, tiny fragment of something will cause a tiny amount of damage. But if the object is big enough, you could have something 10 centimetres in size that will collide with a functioning satellite. There are about 2000 satellites in orbit that we rely on for all of those things - navigation, weather, telecommunications, all of that stuff. It could potentially destroy the whole satellite, and create

more pieces of space junk in the process. So, our big issue at the moment is that there's a lot of stuff in orbit that was launched before there were guidelines in place to try and reduce the amount of debris, and we don't have any proven technology for removing it from orbit.

Michael Veitch

And I presume not much is recycled.

Assoc. Prof Alice Gorman

Not at this stage. There is a lot of potential for that. So there's a company in Australia, Neumann Space, which has been working on the use of metals as fuels for plasma thrusters. And so, potentially in the future we could use metal salvaged from space junk in space, so you wouldn't have to carry as much fuel with you. There's also satellites, which are technically junk because no one's using them, but they still have fuel left and they have instruments that work. So, there's been a few instances where people have repurposed those satellites to use for other projects. They've generally been amateurs. So, there are satellites currently classified as junk that could still be used to carry out scientific data collection missions.

Michael Veitch

Is that one of the jobs of the space shuttle was to go up there and collect things?

Assoc. Prof Alice Gorman

No, they never did that. But they did service a couple of spacecraft. I think Hubble was one of them, was it?

Michael Veitch

And Hubble, of course, yes.

Assoc. Prof Alice Gorman

And that's a capacity we also don't have at the moment. So, there's another Australian company that's working on some transport systems that may involve tugs. So, we may be developing some capacity to do on-orbit servicing. And if we can do that we can also do some on-orbit debris removal, but we are still quite some distance from that.

Michael Veitch

Is there a part of the lower earth orbit, I'm guessing, where a lot of this stuff gets parked, or can be parked? Can it be put out of harm's way? Do we have any control over it whatsoever?

Assoc. Prof Alice Gorman

Not in low earth orbit. So, there is a thing they call the graveyard orbit. This is located about 500 kilometres above the geostationary orbit, which is 35,000 kilometres away, 35,800 kilometres away. So, that's the parking orbit. You can put things there. And if they stay there, which they may not, because generally, at the end of a satellite's life it doesn't have enough fuel left for manoeuvring. Some do, but not all of them. So, they will stay there and eventually start to drift a bit. But that's a sort of a safe place. But in low earth orbit we don't need a parking orbit. If something is low enough or its point of closest approach to earth is low enough, atmospheric drag will pull it back in. The issue is that the rate of re-entry due to atmospheric drag is still less than the amount of debris we create every year.

Michael Veitch

Heavens above, literally. Annie?

Annie Handmer

Sure. One of the other problems, Alice mentioned that we have yet to prove the technology to remove debris once it's up in space. And it's very difficult to do but actually Australia has been working on this. And one of my groups I studied for my PhD was SERC, the Space Environment Research Centre at Mount Stromlo, who were trying to use a giant laser to nudge debris in orbit, and de-orbit it faster. So, to increase the rate of de-orbit due to atmospheric drag. So, to increase that de-orbit speed. But the challenges here are not just technological. And this is something that we look at, it's actually social as well.

If you've got a technology that is capable of de-orbiting or otherwise destroying in some effective and permanent way, a piece of space debris, it is potentially equally likely to be able to destroy, disable, or delete some sort of functioning satellite. And for this reason, it gets categorized as something called a Julius technology, which then means not only that there's a risk that some country might actually be developing a space weapon, or that another country might look at, say what Australia is doing and say, "that looks awfully weapon like with your giant lasers there". But it also means that trying to get the confidence internationally to approve some use of this technology to remove debris down the track becomes harder and harder as we go.

So, it's tempting to say, "We've got the technological solution, that's all we need." And we've got many technological solutions that could indeed work, if you threw a bit of money behind them and a bit of effort. But finding a solution that is politically and socially viable is a lot harder, and I think requires a whole different range of skills to try and make that happen.

Dr Evie Kendal

And can I just jump in there. I was working on a project that was looking at can we create a moon laser to shoot down asteroids that are on an impact trajectory with earth? And the political issues, of course, being what if someone uses it for [inaudible] warfare? What if people use the site to spy on each other? That kind of thing. So, the problem coming up was how do we actually direct this in a safe way? That team determined that you'd have to put it on the dark side of the moon, and just manage the fact that you can't shoot down things that come up from another angle. So, that was the sacrifice that had to be... That was the decision that was made by this team, that that would have to be sacrificed in terms of the scope of the planetary defence it was capable of, in order to avoid the conflicts between nation states.

Michael Veitch

Let's talk to the examples of leadership that's been shown around the world in the space community. No organization of this scale can survive without strong leadership going into the future contemplating all sorts of extraordinary notions and ideas and morals and philosophies. Where's that leadership coming from today?

Annie Handmer

Well, I might speak to that, and go back in time a little bit to Antarctica. There's a place called Lake Vostok where during the Cold War there were a group of Soviet scientists, American scientists, and French scientists who collaborated on a scientific program there. And it was an

incredibly successful scientific program. They developed ice core research. And they also worked on finding a subglacial lake, which is the subglacial Lake Vostok. Now, later on there were some hiccups that came up. But the item of leadership I want to focus on is one of very open-minded and emotional leadership that was shown by the head of the American delegation.

Towards the end of the Cold War, news was slow to reach Antarctica, but the Soviet leader got news that there was a new flag, and the design was sent through. And the Soviet leader went around the station and collected bits of fabric from people in the appropriate colours. And everyone gave them to him. He then sewed himself a new flag. And on Boxing Day of that year, everybody stood around the flagpole while the old Soviet flag was lowered, and the new flag was raised. The point of leadership here I want to point to is that these are countries that had been at loggerheads for decades. And the American leader of this delegation from the US not only had been incredibly supportive of the Soviet colleagues; had been giving all that he could to support their families back in Russia or the Soviet Union. But at this moment, they stood there and they watched the flag come down, and they all cried together. All of these men in Antarctica on the ice cried as the Soviet flag was lowered, and the new one was raised. And there's a photograph taken of them. And when I was doing research into this, and looking into this story it's I think a very beautiful story of how leadership doesn't, in space, as we look to space, doesn't have to be cut in the mold of the right stuff. It doesn't have to be these kind of square jawed, we're going to space and we're basically just machines. We've seen that people do form emotional connections. They do work together in extreme environments, and in doing so, showing vulnerability for each other is a very powerful way of showing leadership even in a difficult circumstance like this.

Dr Evie Kendal

I think it's really important to note that whatever social systems, wherever political legal systems we actually establish in space are the ones that we bring there and consciously create. So we have the opportunity to intervene in some of these capitalist modes, some of these extractivist models of how we would interact in space. And we can actually have something that is more inclusive, more emotionally connected as Annie has been saying. So, we can have leadership models that don't necessarily match what we see on earth at the moment.

Michael Veitch

Well, and in a sense, the analogy between Antarctica and space becomes so much stronger when you think of that because there are so many similar aspects of space, and Antarctica. The enormous space in itself uninhabitable, and humans have to find ways to make it habitable and cooperate, but also protect it at the same time.

Annie Handmer

Yeah, legally, there's a lot of similarities between the Antarctic Treaty, and between some of the space treaties. Some of the wording is very similar. And the Antarctic Treaty system itself has been wildly successful. So, it's often pointed to in international law as a good example of how these things work. It's also a really apt analogy because both areas, space and Antarctica, saw these times of the pioneering spirit. They were classed as the last frontier for man, and we saw people trying to explore them and risking life and limb to do so. And in some cases, losing their lives in the process in both areas.

So, I think it's hard often when we think of Antarctica, this place we can now go on a cruise ship and look at some penguins as a terrifying frontier that was there to be conquered by people like Shackleton, and Mawson, and so on. But if we think about the way that we've used space, we

have gone through that - it's the final frontier phase. And I like to think we're coming out of that into something a little bit less hyper-masculine. A little bit less aggressive, and something more collaborative as we've seen in Antarctica, through an extremely successful period of international scientific cooperation on the continent. It's a wonderful example, and a place where Australia has taken a very important role and continues to on that continent. And I'd like to see us look at what we've done well in Antarctica, and then look at how we can continue to do that well in space, even though we're a small country.

Michael Veitch

What a tantalizing notion. What a tantalizing discussion we've had. Thank you so much for joining us on *Conversations on The Runway* contemplating what the future might look like. I want to go around just quickly, how many years do you think it will be before if, we'll say, when we might be up there in a more permanent way than just the ISS. Annie, what do you think? Will it be at 100 years, 50 years, 20? Your lifetime, you're very young. So, by the time you're an old lady, you reckon we'll be up there?

Annie Handmer

It depends how you define permanent...

Dr Evie Kendal

And old lady.

Annie Handmer

... and old lady. Yeah, that's true.

Michael Veitch

As old as me.

Annie Handmer

Very useful, then. No, look, I think, certainly within my lifetime. I wanted to add that we've talked a lot about the challenges of all of these sorts of things. But I'm actually quite optimistic. We've got a lot of history of working together in hostile environments on earth, in Antarctica, in particular, and I've studied that. We've got this great ability, even internationally, as humans to set aside differences when we're faced with certain death if you open the door. So, I do think that we will end up with some permanent settlements on the moon. And I do think it'll probably happen within my lifetime. And I do think it'll be a lot more successful, and a lot more hopeful than it currently looks as we are mulling around in 2020. That's my thinking on it.

Michael Veitch

Wonderful, Alice?

Assoc. Prof Alice Gorman

2030.

Michael Veitch

Great. Okay. Really? Did you just pull that out of the lower earth orbit that year, or?

Assoc. Prof Alice Gorman

Well, I'm thinking NASA is saying in 2024 they plan to have the first woman and next man on the moon. I think that's a little bit too optimistic. But I wouldn't be surprised if by 2030 there is some kind of more permanent presence in the lunar environment. And I'm also thinking 2030, which is a significant year because that's the year the United Nations Sustainable Development Goals are meant to be attained. So, optimistically, perhaps in 2030, we will be in a better social, ethical, and political position to take on the responsibility of permanent occupation of other worlds.

Michael Veitch

And I bet you'd love to be that first woman on that moon rooting around all that Apollo 11 space junk that they've left up there. I think you'd be very happy doing that.

Assoc. Prof Alice Gorman

In fact, I would not go near them because it would destroy the sites. So, I would oversee everybody else, and stop them from doing that. That would be my role.

Michael Veitch

Final word from you, Evie?

Dr Evie Kendal

Well, I don't really want to speculate on timeframes because I do research in emerging technologies. And I've read papers from 1970s saying that artificial wombs are going to be released in 10 years, and we know that didn't happen. And then there's ones from 2005 that say, it's definitely coming in the next five years, and that didn't happen. So, I don't want to speculate. Hopefully, within my lifetime, but we shall see.

Michael Veitch

Terrific. Don't worry about being ahead of the curve. It's overrated, I say. Assoc. Prof Alice Gorman, Annie Handmer, Dr Evie Kendal, thank you so much for your fascinating input in this conversation on *Conversations on The Runway* today about the future of space. And to Mozart's explicit music, let's contemplate that first opera that will one day be performed we hope in space, and from mine, let it be *Così fan tutte*, with its exclusive aria which says, "Farewell", as the gentle winds carry the ship (spaceship in our case let's say) to safety and happiness, "soave sia il vento".