

# Transcript of 'How to Mine an Asteroid'

## Season 2, Episode 1, Transforming Tomorrow

[Theme music]

**Paul:** Hello, and welcome to Transforming Tomorrow, the podcast from the Petland Centre for Sustainability in Business here at Lancaster University Management School. I'm Paul Turner

**Jan:** And I'm Professor Jan Bebbington.

**Paul:** We're back, Jan. We're back.

**Jan:** I haven't seen you for ages.

**Paul:** I know. It feels like a lifetime ago. A lifetime ago.

**Jan:** First, we're back and we're so pleased to be back as well. So thanks to all our listeners and all the folk who listened to the collections we did over the break between the first and the second series. But we are back. And what are we doing Paul?

**Paul:** That's the question I ask every time we come into the studio. What am I doing here? Why are we bothering? It seemed like an empty summer for me in many ways, not being able to do podcast recording. Although issues of sustainability seems to be just about here, there, and everywhere.

**Jan:** Yes, indeed and I also miss the contact with our colleagues and collaborators from across the world. So it was quite a lonely wee summer without our guests.

**Paul;** Oh, a lonely summer without our guests. But we're back to talk more issues of sustainability. We're gonna be here for the next nine or ten months covering all kinds of topics.

**Jan:** And we've got a fantastic lineup. And Paul and I,,of course, are in the know because we know what the first 12 weeks are already. It's a real feast.

Rather like series one, we'll be going all over the world, we'll be going to different parts of the management discipline, and we'll be going beyond management as well to try to understand what's going on in the world.

**Paul:** Some of the topics I'm really looking forward to discussing, Jan. We're gonna be talking about plastics. We're going to be talking about businesses doing good in the world. [dramatic voice] And we're gonna be going to outer space.

**Jan:** I know, outer space. Um, so if you thought it was a lovely earthly podcast, we are now going interstellar, quite possibly intergalactic.

**Paul:** Intergalactic, that'd be quite a fair way to go. Yes, because our first episode of this new series is all about things such as asteroid mining. And I have to say, when you first said this, I thought you were it making up.

And I also thought that the guest that we have coming up with, who we'll introduce in a couple of minutes, was actually a figment of your imagination. So when you went out to collect the guest and brought him back into the studio, I was quite relieved that you weren't having an episode. And that there is a real person.

**Jan:** But also it is a person, it's not a little green uh, spaceman or anything like that. I've been watching Resident Alien, so I know he could be an alien underneath that, but I think he's a real person.

**Paul:** A real person, so you say. It could be some kind of secret government agent who's just been brought in to get rid of all of our beliefs about asteroids and aliens and things such as that.

**Jan:** Yeah, or to deal with you, Paul. You've attracted the attention of the authorities.

**Paul:** I can fully believe that. Let's introduce our guest then. It is Dr Craig Jones, who is a lecturer in Management and Society, in the Department of Organisation, Work and Technology, and who is interested in asteroid mining.

**Jan:** Yeah, and I couldn't resist this, Craig, so welcome.

**Craig:** Hello. Thank you very much for having me.

**Paul:** Yes Craig, you are real. I was very pleased to see that because I did think Jan had gone a bit doolally saying, oh there's someone in the Management School here at Lancaster who is an expert on asteroid mining. Okay. Yeah, yeah yeah, OK Jan that's fine. But you are an expert.

**Craig:** You're not the first to look at me with, uh disbelief.

[Craig and Paul laugh]

**Paul:** And that's nothing to just do with asteroid mining, that's just general...

**Craig:** ...yeah, just general... [laughs]

**Paul:** ...I'm used to that as Jan pointed out. Can you tell us then a little bit about your background and how you ended working in a Management School when your expertise is on asteroid mining? I'm just gonna keep saying asteroid mining.

**Craig:** Um, so contrary to popular belief, I'm not actually from a physics background or anything. My background's all through geography. So I did all three of my degrees over in the Lancaster Environment Centre. And then yeah, just got hooked on things around mining, extractivism.

And then, basically, this is all an undergraduate dissertation that got massively out of hand. Through doing this, I ended up interacting with different asteroid mining companies, but also other actors within the New Space Economy.

And then through that, kind of have linkages through to the Management School and some of the interests that go on there, particularly around sustainability, extractivism, new kind of markets and that sort of stuff.

**Paul:** So, I think I know about asteroid mining. I've watched Battlestar Galactica and there's quite a few episodes in there where they have to mine asteroids in order to get the relevant materials they need to try and get themselves towards Earth.

And I've also watched the fourth series of uh, For All Mankind, which is a series on Apple. And the fourth series is all about asteroids and reaching the asteroid belt and various issues around that.

But tell me, what is asteroid mining? Not so much in these science fiction programmes I've been watching, but in, in the real world, how does it fit in?

**Craig:** So in the present world, asteroid mining in its modern format, so there have been various ideas around it. I think the first mention actually extends back to 1892, first appears in Edison's Conquest of Mars as a kind of idea.

Um, but then you have renditions in the sixties, seventies, and eighties where it's things around, going off to mine mineral resources there. There was quite a lot of talk, I think it was in the 1980s, about going to the Moon to mine helium three.

But in its current rendition, asteroid mining, really kickstarted in about 2012 with the announcement of Deep Space Industries and Planetary Resources, which were the first two large companies to be set up. I think they announced in February, 2012. They've both since been bought out, but there are now other mining companies as well.

So in its current rendition, no one has actually yet gone off and actually mined an asteroid. A lot of this is about, creating the technologies that are there to do it. And a lot of the discussion is around how do we facilitate, in-space activities to then extend different projects and eventually get to Mars and the rest of the solar system.

**Jan:** And so in terms of wanting to mine an asteroid, am I correct, it's because of the compounds that are there, are they full of rare earth metals, or various other things that we might be keen on having?

**Craig:** Yeah, so that's one dimension. So obviously to mine an asteroid, it is all about the different mineralogy on it, or different elements that can be found there, therefore different reasons.

So one big impetus behind asteroid mining is access to minerals. Broadly construed, the main one that they talk about is access to water, because of the launch costs involved to get, potable water into outer space to facilitate any manned missions, or I should say crewed missions rather. So that's a big one because they can also, then they talk about breaking that down into its constituent elements. So then you have fuel, you've got oxygen for life support systems.

There's also construction, so things like iron and nickel, the idea for that being that they would actually be used in space is the idea using additive manufacturing processes. Because then that way you are not constrained by the particular shape of the shuttles you can build because you don't need to worry about launching them. There's also the fact as well, you can then use as an additive manufacturing process to create repair materials, to then extend the lifespan of craft out there.

There are what are called volatile compounds, which are all your fun little gases and stuff, which are generally found in solids. And then you can start using them to build things like uh, fertiliser and stuff in space. Because they're on the ISS, they're testing out growing stuff.

And then the other one is, as you say, Jan, platinum group elements, but then part of the argument for that would be some of it would be used in outer space, but a key part of the argument would be about bringing them back because many of them are used in uh, renewable energy resources.

So it then feeds into this narrative that's being created around we need to go and harvest minerals in outer space to service a sustainable future on Earth. Whether that be for servicing technologies required for that or because of the depletion of mineral resources on Earth.

**Jan:** And that's fantastic because it's only that last category that I imagined before we, we got to speak on this podcast. But that whole sort of servicing space from space makes a lot of energy sense, if you're gonna be out there doing that sort of thing.

And this is where if you like, because science fiction is always a guide to the near future in loads of ways. Because the other series that I don't think you can have seen is um, *The Expanse*, which is very much about mining, but then also the inequalities that sets up is, is you know, I think one of the most interesting things about that whole programme is then who gets to mine, who gets to keep it.

And Earth in that is the centre of the extractive universe, and everything comes back to Earth and that obviously generates a lot of distrust and eventually war and other madness.

**Paul:** That reminds me a little bit of *Total Recall*, the original *Total Recall*, and Mars being turned into a colony and such and the mining that takes place there, and the inequalities there are between the people who live on Mars and the people who live on Earth and how they're treated. Yeah...

**Jan:** Yeah, we're in the same loop then, the same loop we are on Earth. We're gonna do the same loop further out. And you used a phrase that I found quite interesting that I think our listeners would like to hear more about. You talked about extractivism. What's behind that concept?

**Craig:** Oh, that's a, how far back do you want to go? [laughs]

**Jan:** I'll leave that to you. You're our expert!

**Craig:** So I suppose if you want to take the longer view of it is obviously forms of mineral extraction have been enmeshed within human civilisation since day dot. So you go back to Greeks and Romans, they're mining outcrops of

minerals, and then obviously you've got Iron Age, Bronze Age all named after metals.

So yeah but then I suppose where my research then kicked in was looking at the linkages between the development of early capitalism through to modern day capitalism, and how that's linked with different modes of extraction in some guise or another, normally through mining relations.

Um, so there were different sets of land reforms in German mining areas for rentierism. And that's where they started with rentier capitalism, all the way through to William of Orange changing, making sweeping land reform in the UK, which was about mineral rights in large part. If you're a historian, please don't email me. That's why I say large part. [Paul laughs] There were other dimensions to it.

But yeah, all the way through to now and then, so where my research is picking up now is to look at how those discourses and rationales of extraction from uh, relations with mining now being applied to space. Not just as a kind of, like you say, going into a bigger loop of it all, but also looking at how that interplay between yeah, spatial fixes of capital and spatial temporal fixes of capital now interact with minerals even larger bounded spatial entity.

**Paul:** There's huge issues of course, 'cause as it stands, no one owns asteroids. Or if they do, no one's told anyone that they own them. They're a long way away, they're past Mars, they're between Mars and Jupiter, mainly in the asteroid belt. Is that where we're talking about mainly for asteroids?

**Craig:** Uh, so that's where the asteroid belt is. But there's a lot of discussion on what are called near-Earth objects, which are between, I think it's, if memory serves, it's between 0.9 and 0.2 astronomical units as a near-Earth object.

An astronomical unit is the average distance between Earth and the Sun in a given year. Um, so they're focusing on things that will be coming close to Earth, which, yeah, is much closer than the asteroid belt at present.

**Paul:** But still not exactly...

**Craig:** ...yeah...

**Paul:** ...so, when William of Orange came over from Holland, he had got on a boat and he was here in a couple of hours.

**Craig:** Yeah. [laughs]

**Paul:** You're not gonna get on boat and be at any of these asteroids in a couple hours. Again, historians, please don't email me and tell me exactly how long took William of Orange to come over, [Jan and Craig laugh] because I know he didn't exactly land on the east coast of England, he came in a roundabout way to get to the England.

But right, moving on to, [Jan and Craig laugh] or moving back, I should say, moving back to my point here, there's whole issues of who owns an asteroid. How do you claim an asteroid as your own? Who claims an asteroid as they're own? Is it gonna be a country, is it gonna be a group of countries? Is it gonna be a private company?

There's massive issues that come in here that, so much to think about before you even start mining them.

**Craig:** No, absolutely and it's still an area that is being very largely contested within the outer space community in various disciplines, obviously, particularly within law. So I think, and also lawyers please don't email me, um, I think you could argue there are two camps.

So there's one camp that says, yes, asteroid mining is permitted. Don't worry about it, go nuts. And then you have the other camp which say, no, it's not. What are you doing?

So if we look at current developments, so things around like the Artemis Program in America which has set up the Artemis Accords, which has signatories from different countries. So, I believe the UK is part of it. JAXA, so Japanese space agency. There are all sorts of people that have signed up to it.

Their argument is that they want to help facilitate what's called in situ resource utilisation. So that idea of using the minerals that are already there to do stuff. And if you go onto their website, it'll say it's completely in accordance with the Outer Space Treaty, don't worry about it, it's all good.

In a similar fashion, this was kind of in its contemporary moments, spurred on through the Obama administration's passing of the US Space Act which is the Space Commercialisation Competitiveness Act, or something. I forget what space stands for, but they made a cool little moniker out of it.

So yeah, so their argument was that in their project, people wouldn't own an asteroid, they'd just had the rights to whatever they could get, they could then

sell. Don't own it, but you can sell it. I think it's an interesting mode of logic, if you wanna call it that.

So yeah. And then you have the other camp which say no it's not permitted by the Outer Space Treaty. It says that sovereign states can't exert sovereign ownership, and this is where a lot of the wrangling comes around is 'cause when the Outer Space Treaty was set up and signed, it was nation states that were involved within outer space.

Whereas now there's an increasing commercial and private sector becoming involved. There are some acts within the Outer Space Treaty that do address that, which is basically any issue involved would actually land on the sovereign nation state that's involved with the private company.

But then of course there's wrangling because you could be registered in Indonesia, launch from America, have your stuff land in Kazakhstan, whose remit is it?

**Jan:** And that's very much the same kind of wrangling that we have about transnational corporations on the ground at the moment. So again, it's quite interesting that these parallels exist even in, in what seems to be like a fantastic world.

So is space part of the common heritage of mankind? 'Cause when you think about the Outer Space Treaty in which states and who gets to send up the rockets and which companies are sending up, up, up things, I'm guessing it's not well, Fiji. [Craig laughs] I think it's probably the existing powerful, rich capitalists.

**Craig:** No, no absolutely. Um, the thesis that I wrote as part of my PhD, was talking basically about how these neo-colonial logics being fed through, not just in terms of the discourses, how we frame, and wish to relate and regulate outer space, but also about who gets access and how those benefits or lack thereof are distributed terrestrially.

**Jan:** And in, in line with the theme in this podcast I should say to our good colleagues in Fiji, please don't write to me, [Craig laughs] it's just that I really like Fiji and I thought it would be a good example of a Polynesian South Pacific state from which we could, you know...

**Paul:** Are these similar issues to which were considered when people first went to the Moon? 'Cause obviously the Americans were the first people to land on



the Moon, they planted the big American flag. They weren't necessarily saying the Moon is now American. But there...

**Craig:** ...yeah...

**Paul:** ...there's great symbolism in planting your flag somewhere.

**Craig:** No, absolutely. So there's, as you say, there's the big point around symbolism of, hey we've gone here and done it first. But I think as well in terms of the geopolitical moment within which the Moon landing happened, there hadn't been significant and serious discussions around mineral extraction.

Not to reduce an entire historical moment of the 20th century to a soundbite, but that was more kind of finger waving at the USSR at the time to prove a point. Whereas now people are, especially with things like the Artemis Program being developed, they want to go and make a permanent scientific base on the Moon and actually interact with it in all sorts of different ways, including its mineralogy.

But then in parallel to that, so in keeping around the theme of the current geopolitical moment, against the backdrop of the Artemis Program and Accords being announced, you had the International Lunar Research Station, the ILRS, being set up, which is a combination of states. So things like Russia through Roscosmos, and China, all sorts of. A

nd kind of is an illustration of how these um, kind of geopolitical cleavages have running around now is June last year in 2023, India announced they were gonna join the Artemis Accords. On the same day, and to much less renown and fanfare, Pakistan announced that they were gonna join the ILRS because we don't wanna be involved with India.

So yeah, this is where you then have the conversation around the, is this uh Cold War 2.0 or Space Race 2.0 more.

**Paul:** So we talked a lot about politics. I want to know how sustainability fits into all of this, then. Where does sustainability issues emerge when it comes to this New Space Economy?

**Craig:** Okay, so you have the argument being made by advocates for the New Space Economy, which is Earth is up a creek without a paddle. We need to act more sustainably.

So one argument is that you can take, some polluted industries off Earth and then go run them in outer space. There you are, there's no problem anymore, don't worry about it.

The other one is around, like I was saying earlier on, about degrading mineral qualities in certain deposits. So the argument being we need to go off Earth to find all these minerals so then we can actually service sustainable futures.

Some proponents who look a bit way further forward into space futures also argue well, actually if we go and set up a Martian colony, then that can remove some of Earth's population, make it more sustainable.

But then it's also a backup civilisation, if anything does happen to Earth. Yeah, that is...

[people talking excitedly over each other – inaudible]

**Craig:** ...the look Jan just gave me is how I feel when I hear it.

**Jan:** It's dark stuff! [laughs]

**Craig:** Yeah, everything's ruined. Move away.

**Paul:** My daughter actually asked me what the, oh, only a couple of days ago. What will happen to Earth when, what will happen to the people on Earth when Earth no longer exists? And so it's well I don't really know what to say there. It's many, hopefully millions of years away when the Sun goes supernova and swallows the Earth. But, will people have managed to move away from here then? If they do, they'll have to move a darn sight further away than Mars.

**Jan:** Yes.

**Craig:** Absolutely. So that's one dimension of the sustainability agenda, if you will, for the New Space Economy is move things away, but we can also get the resources to service things on Earth.

But an area of research that I'm starting to develop now are questions, because I think when people talk about outer space, they obviously automatically go to outside of Earth's remit. But if we look at things like greater Earth orbit and lower Earth orbit, which are different kind of distances from Earth's surface. So it's where you get orbital slots for satellites.

There's a growing issue around space debris and space junk. So you know, you get great things like cars floating around in space, if you wanna go on a particular stunt with a Tesla. But then you have more serious ones like old satellites and stuff that have been decommissioned but have been left floating around.

So there was a crack in the ISS space station's window a few years ago that caused a bit of concern. They believe that to have been a fleck of paint from an old satellite because of the...

**Jan:** ...oh wow, that small....

**Craig:** ...velocities at which things are traveling. So, there's that dimension.

Also to note as well is in the past year was the busiest space launch for satellites. So I think it was 3,700 new satellites are in orbit now...

**Jan:** ...heavens...

**Craig:** ... 'cause people are starting to wanna make mega-constellations, which is obviously great 'cause then it brings different communications and stuff to remote parts of the world, but then how do we go about managing that in terms of the orbital slots?

And then if there are big collisions and debris issues aren't sorted, and left is a sustainable orbital slot, a guy called, coined the term Kessler syndrome back in the 1970s. The argument being that if you have one collision between satellites, that obviously then creates a debris field, which can then cause a cascading effect, and then you can't have anything orbiting Earth.

So that's kind of the orbital slot sustainability aspect, but then there's also the terrestrial dimension as well. So obviously rocket launches create a lot of pollution, whether that be through our traditional thoughts around NOx or carbon dioxide, but also things that we don't really think about when we think of space launch, but like black soot.

Normally when we're talking about these issues of pollutants, we're talking very much around the lower elevations of Earth's atmosphere. But obviously with a rocket launch, they very neatly spread it through every layer of the atmosphere. Which then has implications for how long those pollutants will actually still be kicking around because of the different forces that they're then subject to throughout each layer.

Another thing as well, which I would like to see more thought around, is when we crash things in back into Earth, we normally dump it into the ocean. Uh, there's actually a graveyard in the South Pacific of the old space junk, which is just left to sink to the bottom. I don't know what chemical components they're made of, nor what they're leaching, so that would be interesting to know. So, yeah.

**Paul:** Its interesting. I was actually listening to something only in the last few days about the pollution that is caused by space launches as opposed to the pollution caused by airlines. Now, obviously there's an infinite number of more aircraft launches, but the point was made that the fact that these um, spacecraft are going higher up into the atmosphere, there's the potential for damage to something like the ozone layer...

**Craig:** ...yeah...

**Paul:** And obviously the Montreal Protocol was introduced 30-something years ago which was meant to combat that hole in the ozone layer and proved to be very successful reducing ozone gases, et cetera and all the damage that was done there.

But the potential that if we have an ever-increasing number of space launches, is that actually going to undo the repair work that's being done to the hole in the ozone layer? And that's fascinating because yeah, the space launches going so far up, they're producing gases in the atmosphere, producing detritus, all kinds of waste and stuff. The potential consequences of increase in space flight is just things that you never even thought of?

**Craig:** No, absolutely. I mean, 'cause obviously the Montreal Protocol banned CFCs and stuff, but obviously that's at a terrestrial level, so those chemicals have to struggle to get up to the ozone layer to damage it properly, whereas obviously yeah, with space launch, you're just injecting it straight into the middle of it. So maybe we need to think about it now before we wreck it all.

**Jan:** So I've got a question, and this is a question on behalf of Paul 'cause I'm his consultant advisor...

**Paul:** [sarcastically] ...and I don't have a voice of my own so Jan has to speak for me... [Craig laughs]

**Jan:** Should Paul invest in asteroid mining and can he?

**Craig:** So a caveat to this, this can't be construed as formal financial advice.  
[Everyone laughs]

I'm just putting that out there now. I've already said lawyers don't get in touch with me, but definitely don't get in touch with me now.

**Paul:** I'm afraid that because this was specifically framed in the, can I do it, I'm the only person who can sue at the end of this if my investments go down.

**Jan:** You can't, 'cause he's done a disclaimer.

**Craig:** That's fine. I've already given you the caveat unless you edit it out, but now I've got a witness.

**Jan:** Yeah...

[Craig laughs]

**Paul:** Jan won't be able to testify. It's fine.

**Jan:** [laughing] I'll be floating in space by the sounds of it!

**Craig:** But um, so the only kind of things that I'm presently aware of that actively invest within asteroid mining are venture capitalist firms. So if you have enough to get in touch with 'em, places like I think Space Angels is what they're called. You can have a chat with those guys, because they purportedly invest in the top 1% of space companies. Uh, so you can go on their website and have a look through their portfolio if you wish.

Many of the asteroid mining companies currently kicking around are still in the seeding stages. So generating funding through that route. If you wanted to actively invest in asteroid mining, you probably have to do it through a tangential route of investing in firms that are developing related technologies.

I'm just trying to think of any examples off the top of my head.

**Jan:** You don't have to. I mean, yeah, because you're not recommending them to Paul.

**Craig:** Yeah, no, that's a fair point.

**Paul:** Not necessarily the company name...

**Craig:** ...yeah, do your own research Paul. [laughs]

**Paul:** Thanks Jan, you've got me in trouble here. What sort of technologies do you mean then? You necessarily need to name companies, but what sort of tangential technologies are you thinking of?

**Paul:** Okay. So it's things like, so the ones I know mostly about would be Planetary Resource and Deep Space Industries, which no longer exist, but in their plans they were developing things around satellites that were specifically designed for prospecting.

So it's companies that are involved in those areas or that kind of are looking at doing things around a spectroscopy in outer space. The idea being that could then look at a near-Earth object, scan the surface of it, and through tagging it, will know roughly on the surface what proportions of minerals are on it. And then you can put that through your little rationale matrices and decide which one you wanna target from there.

There are also a lot of companies as well involved around launch capacities to try and service it. So things like oh, I forget their name, Spin Launch who are trying to get rid of the pollution issue within outer space by launching satellites into space through centripetal force or centrifugal force. I can never remember the difference between the two.

**Jan:** It sounds like it's a rubber band.

**Craig:** Yeah. But yeah, the idea is literally spin it really quick and throw it up in the air, is their idea.

**Paul:** My question here, is this a similar situation to when you had VHS and Betamax? And if you pick the wrong one uh, the wrong company that's trying to develop something, you lose all your money, but if you pick the right one you're away?

**Craig:** I think at the moment with how things are, if we step away for a moment from the asteroid mining dimension, a lot of their present manoeuvres fit neatly within the larger remit of the New Space Economy, which according to places like Statista and Euro Consult, are still growing quite largely, particularly within the satellite and communications sector.

But then also some analysis I was reading the other day was saying that in the next 10 years, it's not just around satellites and communication, it's all also set to grow by, I think it's 10% minimum within areas involved in the manufacturing, construction and development. So really, I think unless you go

for an absolute bonkers idea. I think if you pick anything that's floated, you'll be fine. [chuckles]

**Paul:** And here's the question, 'cause we've talked a lot about green investment in the past and you know sustainable investments, responsible investment. Would you think it was both a sustainable and a responsible investment to invest in these companies? Or is it purely for the money?

**Craig:** I think it depends on how you wish to approach it and the company in question, because you have some companies who are out and out just involved in space tech, that's their application they just wanna do, do science, 'cause apparently we can use science as a verb.

But then of course you have other companies, so you know, like famously like Boeing's involved in it. But then, they're partnered with Lockheed Martin, so arms manufacturing. There are all those sorts of questions. So I think it boils down to if you want to invest ethically, you're gonna have to do the research on the company itself.

But then another big sustainability question and ethical question that I have, that a colleague and I are trying to start working on, is around what minerals are actually used within the space industry itself and where they come from.

Because I don't quite know how they account for whether or not they've got conflict minerals in their supply chain, as an example. Not saying they do, I'm saying I would like to know how, or if, they do.

**Paul:** So, so many potential issues around sustainability and everything, politics, ethics, everything that comes into this. Is there anything you feel that people working over areas to sustainability could take from the asteroid mining, the space economy sector and use to their benefit?

**Craig:** I think um, within the New Space Economy, particularly more speculative areas like asteroid mining, one of the ways that companies are having to create runway funding, if you will, is to think about the spinoff technologies from the early stage and kind of think creatively around what are we gonna do now?

'Cause obviously it's all well and good, so I'm gonna go mine the living crap outta this asteroid, in 20 years, what are you gonna do now? So I think maybe one way of doing it is yeah, to look at how, from the inception of an idea, what

spinoff technologies can be developed on the way, and how can they actually benefit either people or existing missions as well.

**Paul:** How optimistic are you for the future in this area?

**Craig:** The area as an industry, pretty optimistic, especially the larger context of the New Space Economy. I think it's doing great things in terms of, delivering communications to incredibly remote areas. There have been startups that are currently using geospatial data to map out areas of increasing flood risk, but also help with kind of like agricultural pursuits as well.

In fact, the Indian Space Research Organisation has a very good page all about their different spinoff technologies. NASA and the European Space Agency have those as well. Things they've developed as part of space programmes have then been used in medicine, construction and have sorted all sorts of things out.

In terms of the broader scope of mining the living crap out of everything, I think people will go off and do it because there are enough people with enough influence who want to go and do it. I think for me, I would be more optimistic if I saw a clearer strand as to how that was gonna benefit the widest swathe of people possible.

Uh, particularly going back to Jan's point around how it's not equally distributed in terms of access. I'd like to see a better distribution of benefit as well. Whether that be fiscal or end stage application.

Does that strike a positive enough note? [laughs]

**Paul:** [deadpan] It's about as positive as I normally am, so it's fine.

Craig, it's been wonderful having you with us here today. So many subjects I never thought we'd discuss on this podcast. Thank you very much for joining us.

**Craig:** Thank you both for inviting me. It's been a pleasure.

[Theme music]

**Paul:** Wow, Jan, that was one way to start the series, wasn't it?

**Jan:** It was indeed, and I was so pleased to bump into Craig, and I just immediately thought he has to be a guest.



**Paul:** It was just, a discussion I never expected we'd have, as I said to him, talking about all these random issues that you would never have necessarily immediately thought about when it comes to asteroids, and then sustainability, and how everything ties together, and all the particular issues that there are. There's just so much of it.

**Jan:** And I immediately went into the ocean because the equivalent, you know, sort of themes are being played out in and around deep-sea mining, for example.

**Paul:** Mm-hmm.

**Jan:** So really complex governance questions of economic and political power, and who gets to do what. But then also the rationale for deep-sea mining about acquiring materials to allow the, the green revolution. So in that respect, I thought if taking it off planet, if you like, complicates it further still, but those complications sit in areas of the ocean that are beyond national jurisdiction as well.

**Paul:** And it seems like science fiction, but it's probably not that many decades away that this is gonna become a realistic issue. If you think about going to the Moon, it was the start of the sixties when JFK said, we're gonna go to the Moon by the end of the decade, and a lot of people were laughed at him.

And he said, we know it's not gonna be easy, but we're gonna do it. He said it a lot more eloquently than that. I think he said, we do these things, not because they're easy, but because they are hard, however he said it.

And it's gonna be the same with this it's, there's gonna be a sudden acceleration and then it'll be happening and it'll be just a part of everyday life, albeit a part of everyday life that's still quite extraordinary.

**Jan:** And I was really interested in the intersection with the ozone layer and that political and legal agreement was terrestrial in nature, but when you go up into the atmosphere, it doesn't apply in the same way.

So again with my sort of passion and obsession around the ocean, you know, what's terrestrial and what's oceanic really differ. But I hadn't thought of putting atmospheric into that as well.

**Paul:** Yeah, it's just fascinating. So, we, you say there about the links between the extraterrestrial and the oceanic. Next week we're gonna be going oceanic.

**Jan:** Yes, indeed. Who have we got?

**Paul:** Uh, we've got Frida Bengtsson, who is from the Stockholm Resilience Centre. You may remember a while ago we had Henrik Österblom, who was our guest from there talking about SeaBOS, which is the Seafood Business for Ocean Stewardship Project. And Frida also used to be with Greenpeace. So there's gonna be lots and lots to talk about there.

**Jan:** And I think she'll be really smart on that political angle. I know she will, 'cause she's a, a super colleague of ours. But also then thinking about the move from activism to academia to business collaboration, I think that'll be also a really interesting set of themes.

[Theme music]

**Paul:** Can't wait. Well, thank you very much for listening, and until next time, I'm Paul Turner.

**Jan:** And I'm Professor Jan Bebbington.

[Theme music]

**Paul:** Woo.

**Jan:** Woohoo.

[Theme music]