

Space Capital S01E04 - Fueling Our Space Future with Chris Lewicki Transcript

You know, we don't have a land industry, we don't have an ocean industry, we don't have an air industry. We need to stop thinking about space as an industry. Space is a place. It's a place where we'll do business. And the resource is just really a new medium for doing those businesses in the way that the Internet was a new way of doing commerce.

Welcome to The Space Angels Podcast, episode four, Fueling Our Space Future. I'm your host, Chad Anderson, CEO of Space Angels - the world's leading source of capital for early stage space ventures. The purpose of this podcast is to provide Angel investors with the context and information necessary to understand the real risks and opportunities in this dynamic new entrepreneurial space age. In this episode, we'll be addressing the high cost of deep space missions, and how one innovative company is planning to drastically reduce the cost of bringing us to the Moon, Mars, and beyond. One of the big limitations to space transportation today is that you need to launch with all the fuel you'll need to get where you're going. That's a lot of fuel. It increases the size of the rocket and the cost of launch. The good news is that there is a better way. Our guest today, Chris Lewicki, CEO of Planetary Resources, wants to change all that. Their technology enables rockets bound for Mars, and other destinations, to carry five times more cargo than what's possible today without simply building larger rockets. The asteroid mining company plans to make this possible by refueling launch vehicles in space with water extracted from asteroids. In this episode, we're discussing asteroid mining, how it works, the market opportunity, and who's going to pay for this water. So, Chris, welcome to the podcast.

Chris:

Thank you very much. Excited to be here.

Chad:

So Planetary Resources is an asteroid mining company. Can you tell us exactly what that means, and what you guys do day-to-day?

Chris:

Asteroid mining is turning science-fiction into our reality. And Planetary Resources was founded so that when you go into space, you don't have to bring everything with you. We're developing the resources specifically off of near-Earth asteroids, starting with water that we can turn into fuel that will really redefine and transform transportation in space. Maybe the simple way to describe it is we are a mining company operating in space. And we aim to provide resources for the people and the products they'll build in space.

Chad:

And so, you're day-to-day, what is that you guys do in the office? I know you've got... an office in Luxembourg, as well. How big is your company now, and what are these people doing?

Chris:

Well, we're developing space technology. We're about seventy people worldwide. Redmond, Washington. Washington, DC. And now in Luxembourg, as well. We are creating technology.

Using small satellite technology and sending it into deep space, where you've got stronger propulsion requirements, you've got a harsher radiation environment, and communication ends up being more of a challenge. So, there's a lot of things that we have to innovate, kind of, over and above a lot of what we've seen in Earth orbit so far. In doing this, we have been using the CubeStats, the CubeSat standard, to do a lot of experiments. We started with the Arkyd-3 several years ago, launched in the space station, tried out some new architectures. We are about to launch the first of the Arkyd-6s. And this adds the sensors onboard, and that's really what we're moving in the direction of. Is creating sensors that allow us to detect the valuable minerals, and the hydrated materials on asteroids. So, we're flying an infrared sensor that allows us to do that, and what we learn from that will apply to the deep space spacecraft.

Chad:

Cool. So, a little bit more personal now. Can you tell us a little bit about yourself, your background, how it is that you came to be CEO of an asteroid mining company?

Chris:

It was fate, I think, at the beginning. I am an aerospace engineers by training. A Bachelor's and Master's from the University of Arizona. And it was probably the Voyager-2 flyby of Neptune that got me into the business back in the late-80s when I was in junior high. And I saw that and kind of instantly knew that's what I wanted to do. I had a brief detour with rock and roll in my teenage years, but came back from it, when into engineering. And the University of Arizona, in particular, was a fantastic environment to be a space interested engineer. Because they were just involved like all of the NASA missions. The Planetary Science Department, where I worked, was involved in a lot of these things. They had- I worked on the Mars Observer very early on and got to be involved in a lot of the other early Mars missions. But that trajectory took me to NASA, to the Jet Propulsion Laboratory, where I got a job as a system engineer on the Spirit and Opportunity Mars rovers. And that was a wild and wonderful ride. Which for my colleague-former colleague still continues on Opportunity, which is still roving today. But I got to help design and build, and test and launch, and operate, and then ultimately be flight director for both of those missions. And then one more Mars mission. I helped on the Mars Phoenix lander. Which landed North of the Arctic Circle and dug up water ice on Mars. So that's maybe where the relationship with water started. Water is everywhere in the solar system now, and it turns out it's the most important molecule in the twenty-first century in the exploration of space.

Chad:

Fascinating. So that was another question of mine. Is many of our listeners are investors, and they're considering space for the first time. So the question was about the market opportunity, and you're saying that water is the oil of the twenty-first century. What does that mean, and what is the value of water in space?

Chris:

Well, yeah, I guess you have to go in that, you know, we're all earthlings on the surface of this beautiful planet, and it takes rocket science to get us into space. And, you know, that is the phrase everyone uses to describe something that's difficult. And getting into space is extraordinarily hard, and it's because it is an exponential challenge. The more that you want to send in space, the bigger spaceship you need. The bigger your spaceship, the more fuel you need.

The more fuel need, the bigger your rocket needs to be. And so and so forth. And it just feeds on itself. Just to get to Earth orbit is an incredible feat. And it's such an incredible feat that if you took the same amount of fuel, or the same amount of orbit, and put it into that same rocket again once it was in orbit, you would be passed Pluto by that point. So, you know, once you get into low Earth orbit, you're halfway to anywhere in the solar system as Robert Heinlein said. So this is where, when we talk about water in space, this is where you get to kind of think about a bigger future than the one that we have been doing for fifty years. Which is bringing everything we would ever need with us on the camping trip, and then retreating back home once the camping trip is over because it's too hard to stay out in the woods permanently. There's no streams, there's no food, there's no trees. You know, we have to take the air we breathe and, you know, we can't get on the trail and walk either. We've got carry enough fuel to get us to where we're going next. So when we can bring water from asteroids, or from the Moon, or from the surface of Mars, and refuel our spacecraft, now you can do what Jeff Bezos did with the New Shepard, and what Elon Musk and his team at SpaceX are doing with the Falcon-9, and start to reuse part of your system. And we're reusing the first stages now in the rocket by having fuel depots in space. We'll not only be able to start to reuse, perhaps, the second stage, but have a completely different type of vehicle in space. And one example I like to give, Chad, is when, like, you land at the airport. You're in a, I don't know, let's call it a 737 today. And today, the way that we do transportation in space, is like landing the 737 and then taxiing the 737 all the way to your hotel. And of course, it doesn't really work that well to do it that way. We would develop different vehicles that are better for that other part of the trip. But we haven't really done that in space yet. Or if we've done it that way, we've, you know, we ship the taxicab in the 737, and then we get it out of the 737, take it to the hotel, and then throw it away. So, by being able to have fuel depots in space, what we're essentially allowing is, you know, the Uber economy in space for you to have space tugs, orbital fuel depots. You know, water is, of course, important for people to drink and breathe, and for manufacturing. And then there's a little item that you can use it for radiation shielding, once you get on your way to Mars, or outside the Earth's magnetosphere.

Chad:

That makes a whole lot of sense when you think about it, in terms of the vehicles that we're using. Purpose-made for the different types of missions that they'd be doing. Basically, evolving beyond just the ever-larger rocket.

Chris:

And it feed on itself. You know, when we set out, you know, in our history, when we got the airline industry really going, we had to go- we changed from going point-to-point to a hub and spoke model. To where all the big long-haul flights, you know, went to the big airports. And then you take a smaller puddle jumper from that airport to maybe a different city. And this really allows you to do that in space. And what's exciting about it is the more that your transform this, the more that getting into space becomes important. And making that cheaper accelerates the whole thing. Putting more infrastructure in space, using more resources in space, and this is why, you know, analyst firms, like Goldman Sachs and Morgan Stanley, are talking about space being a trillion-dollar economy in the next fifteen, twenty years.

Chad:

And it's a beautiful thing. I mean, we don't have to reinvent the wheel, right? We're taking lessons that we learned on Earth and applying them to a new environment, just like you said with the hub and spoke model. I was the analogy a lot of times, in terms of the development of the space industry and looking at human space flight and looking at what's happened with the airline industry over time. So, I think there's a lot of analogies that we are now leveraging from our terrestrial experience into space, and I think there's a lot of lift that we can get from that. When I have conversations with investors, a lot of times they may think asteroid mining and fuel depots are a cool concept. But usually their immediate reaction is regarding timelines and, you know, this must be a twenty to thirty-year proposition. I'm curious to hear how you respond to that. Especially considering that your first prospecting mission is slated for 2020. Is that correct?

Chris:

That's correct. And we are a mining company operating in space. And mining companies have very long timelines. A lot of times going from a discovery all the way to production can be twenty years if you're mining gold or copper. You know, maybe the energy industry and oils is a bit faster than that. But what we fundamentally are today is an exploration company. And there's a value chain in mining and resource development that, this is one thing that I often educate people for, is like there are mining companies who make money long before anything is ever pulled out of the ground. And it's in developing, you know, what they refer to as the properties. It's finding where the next copper mine is going to be. It's going to inform the investment risk in it. And then having the information, and having the ability, whether that's through a team or whether that's through technology, to then take the next step with that. And scale it up and get into production. So, what makes asteroid mining, I think, audacious and more challenging than mining today, is no one has done that whole thing yet. And it's a little bit bigger step than it was, say for example, at Sutter's Mill in the early days of the California Gold Rush when all you had to do was look for the shiny stuff, when you were walking up the stream, and then just pick it up. So, we do have an advantage though on present day mining, where we can do some of our prospecting from the comfort of our desks and computer screens. To where astronomy and telescopic observation can know a lot more about one of these asteroids that might be a hundred million kilometers away, than we know about a gold deposit that's a kilometer beneath the Earth's surface, cause there's nothing between you and vacuum and these things are a lot more pure. So, from a business model, we have the opportunity to develop it like an exploration company in mining. We are gonna develop, and have developed, a lot of technology that's... that's really innovating in small satellites, and deep space exploration, and remote sensing. The Arkyd-6 that we're launching, for example, is going to have the first commercial mid-wave infrared sensor on it. It's never been commercially deployed into orbit. And we'll be able to get a lot of beneficial images of our planet Earth while we're calibrating that image and that instrument. So, you know, our time scales are, like you said, four years or so to start the exploration phase. A few more years to learn from it. And then into the development and scaling it up phase. We're operating this the same way that a mining company does, in terms of using standards and financing it in that industry.

Chad:

So, touching on that, where is it exactly that Planetary Resources is focusing? Where is that you're working with other partners, and what else, I guess, in the mining life cycle is still out there to be addressed?

Chris:

Yeah. Good questions. So, it's likely that Planetary Resources will have to develop and deploy the specific asteroid mining technology, and the research and development to support that. And that helps us, again, prioritize the important information that we're gathering. We're probably also gonna have to bring the raw material. And what we expect the raw material to be is to extract it from the asteroid in the form of ice. Plain old simple ice cubes that we can keep at cold temperatures in space, and then bring that back to the point of need or the point of use. Where we start to intersect with other partners and businesses, is probably gonna be in the fuel depots. So there are a lot of private companies, as well as NASA funded work, that has looked into cryogenic fuel depots and the process of electrolyzing water, and turning that into liquid oxygen and liquid hydrogen. So that's probably a place where we'll be, you know, we'll maybe be the pipeline delivering the raw crude into the refinery. But we, you know, there's kind of- there'll be some handover to the refinery to the gas station itself. And we probably, in the long-term, won't be the gas station operators. And similarly, we're seeing development of all of the end users. Whether it's the trucks, you know, that are gonna fuel up. One example in this area is United Launch Alliance as the aces architecture that they're looking at. It's a refuellable architecture. SpaceX, of course, has the newly updated BFR architecture, which uses in-space refueling. NASA's own architecture, as they're looking at options for the deep space gateway with... what's going on with their deep space exploration plan, they're looking at refueling. So those are kind of the parts of the value chain that will probably, you know, have to be the first to do it. And then, like all businesses, we'll figure out where the most lucrative and profitable parts to be in will be. And today, I guess, to just kind of close on that question, one of the really exciting things from an investment standpoint and from an opportunity, is there are, you know, the idea of the best resources out there. You know, there was one Spindletop in Texas, there was one Yukon Gold Rush and one California Gold Rush. And there's gonna be one big moment for resources in space. And at Planetary Resources, we think that's gonna be off of a near-Earth asteroid, and we'd like to be the first ones to bring that to market.

Chad:

Awesome. Chris, can you talk to us specifically about the exploratory part of the work that you're doing? And how is it that you go about which asteroid that you're gonna go after and mine?

Chris:

So, we're building spacecraft to do that. And while I describe this, listeners, if you're in front of your computer - don't do this if you're driving, I guess - but go to Planetary Resources dot com, and there's a video on the website that you can watch which describes our exploration mission. And before we ever send anything into space, we actually use the data that NASA, and other agencies, have collected about the asteroids, to help go from seven hundred thousand asteroids, you know, down to just a few hundred. We then use some additional telescopic observations and proprietary data we've collected to get down to, really, a small target list. Let's say, four or so that we're gonna go out and now need to take a very close look at. But we'll have- we'll have been very specific about the carbonaceous asteroids that we're most interested in. And this is where our exploration mission begins. So, we're deploying a small satellite, much smaller than the ones that any of the space agencies built. And, of course, a lot cheaper. These are things that

will probably be, you know, per asteroid will be a few tens of millions of dollars for one of these missions, as opposed to, you know, the current NASA mission is about a billion dollars to go to go to their carbonaceous asteroid. So, we will deploy, let's say, on a... on a Falcon-9 or another large rocket out to a trajectory in, kind of, shares the orbit around the Sun, like a Lagrange Point. And from there, over time, we'll deploy several different spacecrafts to several different asteroids. And we'll target each individually. So, it'll take, you know, sometimes just a few months, sometimes the better part of a year, to make that journey out to the asteroid. And then when we're there, that's where the really interesting part comes. This is where we do the mineral mapping. And we use infrared sensors that we've developed. We'll use framing cameras. And we're also deploying a surface probe, actually, several surface probes down to areas of interest on the asteroids. And these are little rocket-propelled devices that actually punch into the surface, get a little bit below the surface, collect a little bit of a sample, and this will technically be the first asteroid mining that we've ever done. Cause, in this case, we'll collect a little bit of a sample and we'll take it through the thermal cycle that will bake off the hydrated minerals from the... from the native carbonaceous material. And we'll be able to directly demonstrate that we've made a little bit of water from the asteroid. And from that, we'll be able to get what any miner wants to know, which is grade and tonnage and mineralization, which helps us then take the next step. So those are the parts that we're focused on, and our technology, really the innovation, is doing what used to take a billion dollars and a thousand people and a government agency, you know, now doing it for millions of dollars and dozens of people and a private company.

Chad:

So, I imagine that many of our listeners probably watched Elon Musk announce SpaceX's new BFR launch system in Australia a few weeks ago. And it looks like they're planning to launch humans, and then take tankers and launch those, and refuel the human spacecraft before it heads off to Mars. You're proposing instead that they refuel at a depot in orbit or somewhere. And, I guess, the question is, how does it make sense? I mean, is it really less expensive to mine from asteroids and develop that architecture? Particularly, if SpaceX is able to do the things, they say they're gonna do, and reduce the cost of launch to a point that they're talking about.

Chris:

Yeah. Well, there was... a lot of progress that has gotten us today, in terms of just the current reality of commercial space development. Whether it is the achievements of private companies like SpaceX, in delivering cargo to the space station, reusing their first stages, and having many successful private launches. What we've seen the Blue Origin team do. What we've seen companies like Bigelow do. And not just... kind of these big... kind of high net worth individual-initiated activities, but kind of the smaller guys too, like the Made In Space and space manufacturing. And Planet with Earth observation, and Spire with weather and tracking services. So, it's just kind of a bunch of different things that have been happening in parallel. The other item to is we've seen the governments get more involved with creating a better legal framework, saying you can own material you pull off objects in space. And then, most recently, the government of Luxembourg starting a whole space initiative. So, a long way of getting around to your question, but I think what everyone is seeing is, really, the inevitability. In that, if we're gonna get off this planet, it's gonna be something that's gonna scale to be huge. Jeff Bezos talks about millions of people living and working in space. And he leaves out- I think he should say, living, and working, and playing in space. Because I think there's gonna be a lot of fun there,

with new sports that will be created. With in-space refueling though, and BFR is a good example, they've got, I believe it was announced, as Elon shared, was eight hundred and fifty tons of oxygen and about a hundred and fifty tons of methalox or methane. Liquid methane for their launch vehicle. And in true Elon style, he plans to deliver it all himself. And I would say, you know, if you're making your own plans, best to rely on yourself. So that seems to make a lot of sense. But I think probably a way to look at it, in terms of scaling the industry to be millions of people living and working in space is, you know, we're not still receiving shipments from England in... in the Americas. We became self-sufficient at some point, and we started manufacturing locally. And we started using local resources and having indigenous capability. And that's really where asteroid mining and space resources help you grow to that future of not just hundreds of people in space, which is, you know, what can- the population of a BFR. Or like ULA's Cislunar architecture, which is talking about maybe thousands of people in space. But all the way out to millions of people in space. There's just no way to do that and ship it all from the surface of the Earth. So, and again, I go back to the airline model. We've got airplanes flying all around world. Very few of them are carrying their own fuel for the return trip. You know, most of them, that fuel gets to the point of use from some other source. And I think what's probably, you know, as a final point on this, is the more that can refuel in space, the smaller rocket you can build. Or conversely, the more payload you can take into space. You know, future 3D printers, future workforce, or, you know, future complex goods. If we can just get the dumb fuel from the simple asteroids.

Chad:

Awesome. So, this is a fun question that I've been waiting for the right moment to ask, and I think that maybe this it. So, my question is, you've come a long way, what was it like in the beginning when you approached those first investors with this business plan? And how has that changed over time now that you've got these other things developing, and you're much farther along on your path?

Chris:

Uh... Like my co-founder, Peter Diamandis, says, "Everything's a crazy idea the day before it's a breakthrough." Or the other way around, you know, "The day before a breakthrough, it's a crazy idea." So, this is where, you know, visionary people with deep pockets, like Larry Page, helped kind of see the potential in this and see the long-term of it, and, you know, made a bet on it. And that allowed us to get started on the topic. And, you know, we're in some sense the ultimate zero-to-one company. In that we are, literally, not only defining the industry, but we are creating the marketplace and helping to advise and implement the policy and regulatory environment as we go along. And, you know, now we have nation states on our cap table, and that's been- it's been a very long journey. You know, one thing that a fellow entrepreneur shared with me, Rex Ridenhour, when I worked with him all the way back at BlastOff, and this was many, many years ago. He has an analogy which he used, and I've shamelessly stolen it sense. Where you can't make all the progress in one area. Like, it doesn't work to like to raise all the money, and then develop the technology, and the create, you know, and then create the product and service the market. And similarly, you can't complete the technology, you know, without the funding. And in our case, operating in a new area in space, the policy and regulatory environment, you know, you're not just going to pass all those new laws and create those new regulatory frameworks, without having a little bit of progress to show for it. So, it like, the analogy, is a three-legged

stool. Where, you know, you would increase the height of one leg just a little bit at a time, and you want to keep all the legs kind of in a very virtuous upwards spiral to where you advance one just enough so that you can go to the next one. And... show to to your stakeholders you've made the appropriate progress, and that allows you to move forward in that area. And then, now, you got to your short leg. And, you know, I've got part A leg, I've got part B, let's move part C forward. And that's been the story of Planetary Resources. We, you know, went with a crazy idea and, just year by year, have moved it forward. Made some steps forward, made some steps back. You know, certainly have taken some detours along the way. But, you know, I think this is the journey of a startup, of finding product market fit, and... bringing a team together. And I think the thing that probably in the last few years that we've seen with all of the other, both government and commercial, players in space is, you know, it's not just what Planetary Resources is doing. It's what everybody is doing. And, you know, all of the Space Angel's companies. We're all contributing a part in the ecosystem. And it's actually making it easy for-easier for everybody else, because everyone's taking steps forward together.

Chad:

Since this is a podcast for investors interested in space and considering space investment, what can they expect in terms of revenue generation? When can they expect to see returns on an investment?

Chris:

Yeah. Yeah, great question. So, one thing, everyone always approaches us and is like, "When are you guys gonna make money?" And it's like, we're making money right now. So we have generated revenue in our history from a variety of things. All the way from, you know, doing technology work for NASA and DARPA, and others. And then an area that we're moving into is actually working with our long-term partners in the mining industry. And we're finding that our expertise in system engineering, in autonomy, in tele-operations, in reliable systems, these are all things that you think about in automating conventional mining today. If you have a haul truck that needs to go, you know, between a hopper to a crusher. More and more they're taking people out of those loops. And, you know, what better way to figure out how to scale those problems and anticipate challenges than to work with a team, a lot of who have been involved with landing rovers on Mars. And tele-operating a rover at the other end of twenty minutes to the speed of light. So that an area that we've been excited to start working with our partners on. From a return standpoint, from kind of the existing revenue, this is again where the model that we really locked into is one of being a mining company in space. And to the mining companies, we are what's known as a junior engineer company. We're developing the resource, we're informing the resource, and we're actually borrowing a financing model from the mining industry, in that Planetary Resources ends up being kind of the picks and shovels company, and the technology company. And that's where the investment in Planetary Resources has gone into. But Planetary Resources will generate revenue by executing exploration projects, in the same way that an exploration survey company might go out and find a new green field, oil field, or a new copper deposit. So that we do under contract to a different entity, a joint venture of mining interests, of investors, maybe sovereign wealth funds. And that actually is revenue into Planetary Resources that we'll be generating over the next several years on our first exploration mission.

Chad:

So how is what you're doing different than, let's say, Schlumberger, and how they got up and running?

Chris:

Well, probably in that, you know, we are dealing with a commodity material, where we're dealing with an industrial mineral that has a price that's agreed to by the buyer and the seller. And there's actually a lot of examples of that. Like, you know, particular grades of aluminum or titanium, or a certain type of chalk or something. You know, you get stuff that's off the spot market for that. You know, I think, you know, the other difference is that no one has closed this loop in space mining and delivering products in space yet. So we don't have, you know, I think a big challenge for many conservative and traditional investors, you know, traditional investors who might, for example, invest in a ten year multi-billion dollar pharma investment. Which is outside most people's investment portfolio. But people know that system, and they know what the risk is involved. And they have some comparables, you know, whether it's Pfizer or... or Bayer, or any other company that's had a big product. They kind of know the system. And that's the challenge that we have in developing a new product in space mining is that we don't. We have to compare it to something that is analogous, but not exactly the same thing. And that's- that's why there's only a few asteroid mining companies around right now. And I think what makes us such an interesting journey to follow.

Chad:

Okay. So, you're the first to 3D print something using asteroid materials as feedstock. Can you talk us through how you did that, where you got the feedstock, and what are the implications for this outside of the water that you mentioned earlier?

Chris:

Now, that was a really fun project that we did with our investor and strategic partner, 3D Systems. And we wanted to find something that would really spark people's imagination about the potential of manufacturing in space. And I'll go through the mechanics of how we did it and then return to that potential. So, we took a very common metal meteorite, Campo Del Cielo meteorite. If you- if you find one on eBay or you see someone, you know, someone in a school or whatever, it's probably Campo Del Cielo. There's tons and tons of the stuff. It was originally found in Argentina. In order to make it work in a 3D printer, we had to turn it into a powder. So we work with one of 3D Systems partners and put this essentially in a plasma furnace, which vaporized it, so to speak. And then created a fifty micron... precipitant, which then was kind of the feedstock that you would put into the 3D printer. And one of the things that they would usually do in this process is they would purify it and they would sift it, and they would make it all nice and neat and tidy. And we insisted that they don't do any of that stuff. It's like, take the dirtiest, most compromised, you know, think of the pioneering building the log cabin, you know, with crude materials and crude tools. I want all the schmutz in there and let's see what we can do with... with raw materials. So, we left all that in there. We then put it into one of their direct laser melt printers. This is a technology that's now gone beyond sintering. Sintering only formed like a local, relatively weak bond. The melt, it's like, it's almost, it essentially has the same properties as forged metals. And then, you know, we- we printed a very- a very short... and small little concept device, just because of the amount of material that we had. But the team that - at 3d Systems - that printed that said that it prints, you know, just like iron. And it tested out with good

material properties, and that was - and still is - the world's only 3D printed object made of alien metals. So, what's super exciting about this is 3D printing, of course, is a twenty-first century manufacturing technology. It approaches it completely different than the history that we've usually made things, which is additive manufacturing instead of subtractive. So you, you know, you print the thing you want. It's not like Michelangelo where you cut away everything that's not David. And where this gets really exciting for space is that you now can make something onsite, like you build a building, or a bridge, or a dam. You can make something with, actually, materials that are already powderized. There's a saying in the gold mining industry that yesterday's tailing piles are today's gold mines. And there are iron materials that are leftover in carbonaceous asteroids that you could pull out and put straight into a 3D printer. But now think about something that is not only built onsite, but now doesn't have to hold its own weight. And it doesn't have to fold up to fit in a rocket. So, you could make it a kilometer-wide and a millimeter-thick, and that would never be a problem for it. And it also doesn't have to go through, you know, that very violent nine-minute journey into space, where it feels several times its gravity and vibration, all that. So, this is, you know, when asteroid mining gets really exciting, and when we'll start to see large space habitats, and O'Neilian habitats, and large arrays. This is going to be the sci-fi future that we've been reading about for so long. It's gonna be enabled with 3D printing using iron, and nickel, and cobalt off of asteroids.

Chad:

Awesome. I have two questions. One that I have to ask, because I know that everyone always asks this. How do property rights work in space? Who even governs that? You mentioned Luxembourg earlier, and what they're doing. I mean, what is it today and how is it evolving?

Chris:

Well, for a long time already, all the laws that you need to go out and explore and asteroid, and to do the prospecting and exploration, already exists. So, getting the launch license, communications license, you know, the review that you have to do for the liability convention and all those types things, registration. All that exists and... proceeding just fine there. What the United States introduced in 2015 was a little bit more clarity with regards to ownership of materials in space. Cause in the outer space treaty, which is, I guess, you can't say it's the law of the land, it's the law of the not-land. Out space treaty says that, you know, that no sovereign nation can claim a celestial body. And they kind of were silent about everything else. It didn't say that you couldn't do commercial things. So, the United States, essentially, passed a law in 2015 that says if you go out to an asteroid and you obtain materials from that, those materials become your property. That the US will recognize your right to be freedom from being interfered with while you're doing that. So, you know, you can't play a game of king of the hill, for example. Kind of like fishing. If I've got my- if I've got my fishing license and I cast my net, and I'm about to pull it onto the deck, you can't come in and cut my net off. So just kind of setting that standard. And then the last thing they just made clear is that, you know, we have to maintain compliance with the existing treatise and other things. So that was a big step forward. And it was a step that was next followed by the United Arab Emirates. After they started their space agency, they introduced their national space policy, which talked about the development of resources in space. And then most recently, this summer, the Luxembourg was the next one and the first in Europe to pass an even more detailed law about ownership of materials in space. And certainly, you know, there will be more regulations and more laws to come. But this is a great framework

to get the industry started, to give investors certainty that these nations see this as a future place to do business. And this is something that I really enjoy the distinction of is, you know, we don't have a land industry, we don't have an ocean industry, we don't have an air industry. And we need to stop thinking about space as an industry. Space is a place. It's a place where we'll do business. And the resources are just really a new medium for doing those business, in the way that the Internet was a new way of doing commerce. So, I think that's what we are seeing, you know, right now in the commercial development of space. And the new space race is that, you know, everything is backed up by business plans, by customers, and a market for that.

Chad:

One last one before we let you go. At Space Angels, it is our belief that there has never been a better time for investors to get involved in space investing. So, the question to you is, do you believe that that's true. And, if so, why?

Chris:

Oh. There has definitely been never been a better time to get involved in space investing. I think the best corollary that I can give that's very familiar to everyone, is to think about the development of the Internet. Which was less than a generation ago, when it really started to be commercialized and when you really started to see business opportunities. And in the very early days of the Internet, when Mark Andreessen was creating the web browser and Tim Berners-Lee was creating the web server. And Jeff Bezos was figuring out how to sell books on the Internet. You had to do all of it yourself. It was full stack. You had to buy your server and get your network connection and install the software and write the code on top of it. And it was just a huge ordeal. And that's the way space exploration has been up until very recently. And what we're seeing now in space, is that it's more like Squarespace, to use a different company with space in the name. Where you don't need to know a thing about building a website. Or you don't need to install a server. You just need to come with your business model. So, if you can provide communication services to space that is something that there's definitely a need out there. And, for me, as a CEO of a company, I now don't have to, you know, provide that service- I don't have to create the service myself. I can go get that service from another company. Similarly, with launch. You don't have to broker your own launches directly with the launch vehicle developer. You can go to intermediaries who will sell you that service. So, this is not only enabling lower barriers to entry for new businesses coming in with business models for space-based businesses, but also it represents new business opportunities to serve the marketplace. And, you know, just like any other industry, there will be winners and there'll be losers. A lot of it's gonna be in defining the standards. The CubeSat standard was an excellent example of a standard that kind of won, and really helped definitize the industry. I think we're gonna see, you know, an orbital docking standard come out. And in-space refueling standard come out. Probably communications standards. And all these things will do to the space industry, what standards have done to Internet and computers and everywhere else will. Now everyone can, you know, build a USB interface and sell to everyone who has that same interface. So, this is really what's happening now, and what's decidedly than the entire history of our work into space. Now there's many more players and many more opportunities to plug in.

Chad:

[laughs] I see what you did there. That was very clever. So, I'm gonna ask you one more. The relationship between Space Angels and Planetary Resources has been long, and we've been involved since the beginning of the company. What do you see the role of Space Angels in the development of the space sector that we're seeing?

Chris:

Space Angels has been great to work with as an investor to Planetary Resources. You know, often it's the case when we have a new person interested in investing in the company that this is their first space investment. They don't actually know much about the industry or, you know, don't know the basics about it. And that's usually not the case with conversations we have with people who come through on Space Angels tours. They're people who have had the opportunity, not only to- to learn from you, but learn from other investors in the community. And, you know, they ask better questions, they have better insights. In a lot of cases, they come with resources, and networks, and references. And that's useful from a company standpoint. It's now a community that we're a part of and we can leverage. And when we need an intro to this company over there, we know we've got a warm connection to get that. So, it's certainly, I haven't seen anything like it in the space community. And if you're just getting involved in space investment, I think Space Angels is the place to be.

Chad:

Chris, it's been fantastic to have you on. Thank you for giving us so much of your time and giving us some really great insight into the future of space and where we're going. It's been great to have you on the show. Thank you.

Chris:

Yeah. Absolutely. I hope everyone is excited, as I am. This is fun. And who knows where it will take us, but we're living in the most exciting time to be alive. And I'm looking forward to humanity being a multi-planetary species.

Thanks for tuning in to The Space Angels Podcast. I don't know how you can listen to Chris and not be inspired. I especially like how he made the distinction that space isn't an industry any more than the ocean is an industry. It's a place to do business. And the types of business that find their place there, some of them, we can't even begin to imagine what they'll be. And as you just heard, there's never been a better time to get involved in space investing. So, I want to invite you to visit our website, Space Angels dot com, where you can learn all about Space Angels membership, and how you can get involved in this exciting new sector. And before I sign off, I just want to put in a plug for our next episode, which will be a special feature, giving you a glimpse into our Space Angel's expedition.