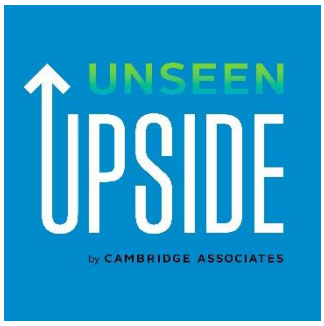

Season Two: Episode Five
Space: Zero Gravity Space Factories
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Krista Matthews: Want to talk about space?

Presley Matthews: Yeah

Krista: What do you want to be when you grow up?

Presley: An astronaut.

Luke Charest: Presley Matthews is in first grade, and she likes reading. And here she's talking about space with her mom, my colleague Krista Matthews.

Krista: That would be really cool. Why do you want to be an astronaut?

Presley: Because I like space, I want to travel there.

Krista: You want to travel to outer spaces? If you could go to space, what would be one thing that you want to do while you were there?

Presley: Be the first person on Mars.

Luke: Space has captured our imagination for millennia. From the Mayans to neolithic Britons to first graders today, humans have always been gazing towards the stars. But looking up wasn't enough for us earthlings. In 1949, the "Bumper-WAC" became the first object made by people to enter space. It was a rocket that climbed to an altitude of 393 kilometers or 244 miles.

Fast Forward 20 years and we had Neil Armstrong stepping onto the Moon for the first time. “That’s one small step for man, one giant leap for mankind”.

For decades, space was a venture of governments and international organizations because of how expensive it is to do anything up there. But in the last decade or so there’ve been a number of commercial players that have made huge strides in bringing down the cost of traveling to space, like SpaceX and RocketLab.

And that affordability has effectively opened space to a whole new world of innovation. You may even hear the phrase – “The new space economy”. But how does all this innovation help us back here on earth? Well, turns out, we can make stuff in space that’s hard to do back here on Earth. Essentially, this is potentially the dawn of space factories!

I'm Luke Charest and from Cambridge Associates, this is Unseen Upside. This season, we’re exploring investments that are protecting or enhancing life on our planet. And talking to the people making it happen.

ACT 1

Krista: Do you look at the stars a lot?

Presley: Yeah, sometimes I stay up late. I have a book about all these astronauts

Krista: Who are some of the astronauts that you've read about in those books?

Presley: Mae Jemison, and she was the first black woman in space. Scott Kelly. He spent the most time in space without coming back.

Krista: How long was he there?

Presley: A year

Krista: He spent a year in space?

Presley: Yeah, without coming back.

Krista: That's so cool. And any other astronauts that you love?

Presley: Sally ride.

Tess Hatch: The first American female astronaut.

Luke: Tess Hatch is a partner at Bessemer Venture Partners, a venture capital firm that has invested in iconic companies like Pinterest, Shopify, Yelp, and LinkedIn. She says that as an adult, Sally Ride returned to her childhood school in Los Angeles.

Tess: So, years later after she had attended, Westlake, had gone to space, she came back and spoke at Harvard Westlake.

When I was attending the school, gosh, I was maybe 12, 13 years old and I don't remember a word she said, but I remember this brilliant bad-ass lady standing on stage, having traveled to space and back and so inspired and simply wanted to be her. So, I started embarking in the journey I've now traveled, but I thought it was going to end as an astronaut, but NASA keeps rejecting my application.

So, I still want to travel to space. I'll just have to get there a different way.

Luke: She may not be an astronaut yet, but Tess has impressive credentials. She holds degrees in Aerospace, Aeronautical, and Astronautical Engineering, and worked for Boeing and SpaceX where she worked with the government on integrating its payloads with the now-famous Falcon 9 rocket.

Tess: I worked in mission management at space X, integrating satellites with its Falcon 9 rocket. And that was an amazing experience.

During grad school, I had no clue. The acronym VC even existed, let alone what venture capital was.

Luke: These days she uses her STEM background as an investor at Bessemer.

Tess: We're currently investing out of our 11th multi-billion dollar fund and we invest at all stages across all industries seed through growth, and we are here to help. Our companies grow into market leading businesses. Last year, three of the companies in Bessemer's portfolio. Rocket lab Spire and Bella 3d all went public. We got to ring two New York stock exchange and one NASDAQ bell.

Luke: Bessemer has long been a successful investor in software companies or - SaaS for short, which stands for software-as-a-service. But the firm has also been increasingly investing in frontier technology like space companies.

Tess: A decade or two ago, SaaS used to be that cooky thing in the corner that is deep tech today. SaaS used to not be as popular as it is. And if there weren't those few investors looking out in the corner about what the next thing would be.

SaaS Would not be what it is today. So, I think it's really important to have a diverse firm, in terms of all types of diversity, but specifically investing in all different types of industries and areas. And who knows maybe in 2, 5, 10 years deep tech specifically space, is that next SaaS.

Luke: You wrote this great piece called spaces open for business back in 2018. And I guess in, in conjunction with VC funding, like what other things are happening in the world that are like creating this new era of like space commercialization, right like it forever, it

feels like it was just NASA and big government programs like, but what happened to kick off this new wave of innovation.

Tess: The invention of the cube sat.

Luke: More on what that is in a second.

Tess: Before the cube sat that was invented in 1998, the only way to get an asset, a sensor, anything into space was a school bus-sized satellite that would take years if not decades and tens, if not hundreds of millions of dollars to design-build, test and launch. And it would go into an orbit called geostationary orbit, 36,000 kilometers away from the earth.

And it would Orbit the earth at the same speed in which the earth was rotating. So, it looked like it would stay above a single point of the earth, seeing a third of the earth at all points of time. That is a really high fricking barrier of entry. Only Apollo, NASA, Lockheed Boeing.

Those were the companies with lots of drive power on their balance sheet that could afford to launch satellites into space. 98', a professor at Stanford and Cal Poly SLO invented this new form factor. The size of a tissue box, a 10 x 10 x 12 centimeter cube, where you can throw cheap commercial off-the-shelf sensors.

Luke: This is the cube sat.

Tess: And rather than in geostationary orbit, 36,000 kilometers in low earth orbit 500 to 1200 kilometers. That opened space for business. Entrepreneurs, students, people flock to this new form factor and through whatever sensor their imagination could come up with. Onto this cheap, a couple hundred thousand.

Remember it's being compared to ten to a hundred million, if not more and throw it up into space. And that is what we're seeing today. 20 years later, we have AIS sensors for maritime tracking ADSB sensors for aviation tracking and GPS, radiological rotation, sensors for weather monitoring and predicting. And we now have better information and prediction about our weather, about our planes, about our ships.

Luke: So, we've got all these companies now operating, in and around space. At some level I'm like the person that loves space, but to the extent, like I just binge Netflix, space X specials right and so, could you help make sense of what are the different spaces or parts of the space economy, that are exciting to you as an investor, but also just as we try to orient ourselves and things of all the companies and industries operating here.

Tess: At the highest level, I view it as four pieces, materials and components and manufacturing techniques that support the entire ecosystem. The entire ecosystem mostly consists of rockets and satellites. Rockets to take the satellites up and down, and then you've got the satellites that are actually operating in space.

Tess: And then the fourth piece is the infrastructure that is required to communicate with the satellites, whether that's, give them tasks on where to look at the earth or downlink data of various photos they've taken of the earth. All of these four things are for Earth's benefit.

Now I hope and really look forward. We could at least add a fifth major bucket in terms of a lunar or a space economy.

Luke: Think of the lunar economy as all the economic activities connected with the production, use and exchange of resources around the moon.

Tess: What I think will happen next is space for spaces benefit. And the first step is NASA's Artemis program which has the intention of landing the first woman on the surface of the moon and creating that lunar economy.

Luke: Artemis is a human spaceflight program led by NASA with multiple international and domestic partners. Its goal is to return humans to the Moon. But before sending people up there, NASA will launch the Artemis 1 mission, an uncrewed test flight that will carry Orion, their new spacecraft built to take humans deeper into space.

NASA Artemis I video: A primary goal of Artemis One: ensure Orion safely returns to earth. Before we fly with humans, when we do we'll build our capability for sustainable lunar exploration, preparing us for missions farther into the solar system.

Luke: This video is from NASA.

Artemis 1 is expected to launch no earlier than August 2022.

I think one of the things that is supremely underestimated about space technology and innovation is that like it has a lot of broader applications beyond just space for space.

You had this great like sentence I'm stealing here. It was like the technology we need to sustain life on other planets will ultimately fix societal problems here on earth. Could you give us an example, I guess that an everyday person would feel and see in their day-to-day life that started from space technology.

Tess: I think it's important just to note lots of people already use space in your everyday lives, whether that's to navigate us to our destination via GPS, whether that's to watch television via direct TV, listening to the radio, Sirius radio, DirecTV, Sirius, GPS, those are all actually names of satellites in geostationary orbit that we're already using every day.

Every time we swipe our credit card that goes through a satellite an ATM. When we traveled to the moon via NASA's Apollo mission. And we landed that first astronaut on the surface of the moon, we wanted to take a selfie, a lunar selfie.

That optic technology was the creation of MRI and CT scanning technology used on our hospitals on earth every day, saving lives, implantable heart monitors, water purification

systems, laser eye surgery. Those are three examples of technology that was actually invented from space exploration

So, I really am confident that when we go back to the moon and beyond, the secondary and tertiary benefits of the technology needed to get to and sustain life elsewhere, we'll solve societal problems here.

ACT 2

Luke: It's probably easy for you to think about manufacturing cars, phones or computers. We are familiar with the production of goods here on Earth.

Well, it turns out there are now people building new companies and technologies that could make something as far-flung as manufacturing stuff in space a reality.

It's called In-Space Manufacturing, AKA in-orbit manufacturing. It basically involves different processes with the goal of producing goods in the space environment. But to understand that environment, we first need to understand microgravity.

Delian Asparouhov: The only reason that people stay in space is because you're going super, super fast, right? You're actually constantly falling down towards the earth.

Luke: Delian Asparouhov is the co-founder and president of Varda Space Industries, a company focused on building the first commercial space factory.

Delian: But you're going just fast enough so that as you're falling down, you basically bend around, the curvature of the earth and you never actually fall in.

Luke: Okay, a quick refresher on Gravity. Gravity is a force in the universe that governs motion. It's what's holding us to the ground and keeps the moon orbiting around our planet. The acceleration of an object with mass towards the center of our planet is defined as "Earth's gravitational pull," and it has the constant G.

The farther the object is, the pull decreases, but it doesn't disappear. However, we have learned to create environments where we don't experience the effects of gravity.

Because astronauts have mass, the gravitational pull is always accelerating them towards Earth - think free-fall. But because they are in orbit there's another force at play. It's called the centrifugal force and it pushes an object traveling in a circle away from its center. Remember the Merry-go-rounds?

This delicate balance of forces with speed and altitude results in our astronauts in the ISS appearing weightless. That environment is what we know as microgravity or 0G. And the effects of microgravity in space can potentially unlock new possibilities in manufacturing!

Tess: I would love if space manufacturing is the next invention of the cube set. If it's the next technical driver and momentum driver in the industry.

Luke: Tess Hatch again.

Tess: Optimistic case. On earth you can change temperature and you can change pressure. But you are stuck with 1G. You are stuck with the amount of pounds that you weigh.

When you traveled to space, that is a new lever that you can change. You can still change temperature, you can still change pressure. But you now have the ability to change the one G to zero G.

Delian: There's a reason why space manufacturing has just been an idea for a long time, but nobody's really executed on it. It's just like the railroads didn't really exist.

LC: Varda co-founder, Delian Asparouhov again.

Delian: You know, the space shuttles is an incredibly expensive railroad, Falcon 9, even the early days was still pretty damn expensive railroad. A Falcon Nine though that can like, launch and fly 12 times now. That starts to be a pretty economical railroad.

Luke: Long before Delian was building industrial parks in space, he grew up in a family of scientists: his mom was an economist, his dad a statistician.

Delian: My motivation, for getting into this field was partially through this realization that I had roughly 10th grade of high school, that I would just never be able to beat my dad in math. So, my dad was a gold medalist in the International Mathematics Olympiad.

Luke: Basically, the highest tier high school mathematics competition.

Delian: And in 10th grade I realized I was doing pretty damn well at math. But I was never going to quite hit that gold medal. So, I realized I needed to do something different. And the thing that I felt like I was doing best at in school was physics and robotics. And obviously the best way to combine the two of those was, space robotics.

Luke: Delian went to MIT and while he was there, he received a Thiel Fellowship, which "gives $100,000 to young people who want to build new things instead of sitting in a classroom." So, he dropped out of MIT!

Delian: I learned everything from sales, recruiting, fundraising, customer support, all these things that, you know, relative to my peers at MIT, they just continue to learn some level of algorithms and high-performance computing, but in the grand scheme of things I actually got pretty far along in that. And, not sure that I missed out on too much. So very much felt the right choice for somebody like me.

Luke: Delian became an entrepreneur, founding his own startup and then transitioning into venture capital. Before starting Varda, he became a principal at the storied venture capital firm - Founders Fund. They've backed some of the most impactful companies in tech and science including Airbnb and SpaceX. In fact, he still works at Founders Fund dividing his time between Varda and Founders Fund.

Delian: I'd say, you know our approach to incubation is quite different than let's say most firms. It's very much like one particular investment partner, doing a, what I call a Herculean you know effort to, both convince the firm that this is something that they should be allowed to spend time on, two that the firm actually you know wants to invest, and three obviously building the whole damn thing. All three of which, are not the you know easiest propositions to overcome.

Luke: And one of these herculean efforts is Varda Space Industries. The company "aims to be the first to build a space station with industrial use, where it will take advantage of low gravity to manufacture things better than on Earth." In other words, they want to be the first Space factory.

Where did the like, seed of this idea, like, are you sitting around investing in companies and you're thinking, boy, we should build stuff in space like where was the seed for this coming from?

Delian: Uh, for me at least it originally started in 2011 when the Google lunar X prize was announced.

XPrize Video: The X prize foundation runs incredible large-scale competitions around the world. That set very clear, measurable objective goals.

Luke: This is from a promotional video of X Prize.

XPrize Video: The first person to build demonstrate this capability wins the prize money. And the world gets the benefits.

Luke: Effectively, they give awards to startups to accomplish specific tasks. The Google Lunar XPRIZE, aka Moon 2.0, was a space competition sponsored by Google between 2007 and 2018. Their goals: motivate affordable access to the moon and give entrepreneurs a platform to develop long-term business models in the lunar economy. Over $30 million dollars was awarded to different projects.

Delian: One of which was just drive a lunar Rover on the moon and stream live video of it. Some were actually related to in-space manufacturing, asteroid, mining, etc. And seeing those companies kicked off my fascination with the industrialization of space. I can't claim that I fully knew it, you know sort of consciously at the time.

But probably this sort of like subconscious belief that the only way to really make sort of space exploration sustainable is through economic incentives the early days of the you

know lunar base or uh, low-earth orbit outposts. They look a lot more like a you know oil rig than like a suite, um at the four seasons.

And so, the only way to convince somebody to, spend time on an oil rig on a regular basis is like, you got to pay them a lot of money, and so then the only way to pay them a lot of money is make sure there's, industrial applications for it.

Luke: The idea of space manufacturing isn't new.

Delian: In the earliest days of, a skylab, NASA already ran several experiments. They were basically showing the promise of microgravity manufacturing.

Luke: Skylab was the first US space station. It was launched by NASA in 1973 and was operated by 3 different astronaut crews for almost half a year.

Skylab Legacy video: 3,2,1,0…The Skylab lifting off the pad now, moving up.

Delian: In studying a variety of different, materials, they, did, metal alloys, protein, crystallization, a few others and then that is only continued, on the ISS.

So that was the original sort of, you know, spark of it. But at the time I was like still in high school. I basically just started tracking these companies, somewhat fanatically.

And then, over the course of like my, eight years, in Silicon Valley. I was maybe somewhat surprised that like, none of those companies effectively, you know, had, success, asteroid mining and space manufacturing, etc, still remained largely you know academic propositions.

And so, then when I finally became an investor, I started to actually, you know, invest in a handful of aerospace companies and realize that just like these companies are started not at the right time. You know and then it only really started to make sense, as, Falcon nine got online

Falcon 9 video: 3, 2, 1… Stage 1. Lift off. Lift off of the Falcon 9.

Luke: Designed and manufactured by SpaceX, Falcon 9 is a two-stage rocket that launched in 2010. It made history in December of 2015 when it became the first orbital-class reusable rocket. Allowing the company to refly the most expensive parts of the rocket. Significantly driving down the cost and extending the lifespan of the infrastructure needed to access space. Here’s audio from SpaceX Falcon 9’s launch and reentry.

Falcon 9 video: [Crowd excitement]

Delian: And I was like, okay, this idea finally makes sense to like actually aggressively, commercially pursue. And so initially my thesis was, let me go reach out to some of these groups that have at least theorized about it or done small scale experiments on the ISS. And let's like discuss maybe funding them to actually now go aggressively pursue this off of

the ISS. Because part of what I realized is just fundamentally the moment that you're on this, like large scale human-rated multinational, research platform, there's just no way like that a venture scalable fast speed, fast scale, business could ever operate within that. And so how do I fund one of these companies to like, do what they were doing, but like off of the ISS and started doing it more commercially?

Luke: Delian shelved the idea but then Covid hit, and everything shut down.

Delian: The one thing you can do in times like this is like start a company, right. So that was the first time where a brain worm entered my mind like, oh shit I might have to actually, you know start this microgravity manufacturing company.

And then right after, the Biden administration announced a second set of, relatively, large, stimulus packages, I was like, oh shit, I know what I have to do. That thing that I wanted, those academic type companies to do. I just have to go do myself. So, let's start talking about, what that looks like, what that co-founding team would look like and what that process would be.

Luke: So, in 2020, Varda Space Industries was founded.

Delian: Varda is building the world's first, low earth orbit manufacturing platform, as well as the hypersonic reentry earth logistics to bring the materials that we produce, back down.

Luke: Delian says there are 2 worlds in space manufacturing.

Delian: One, I call space manufacturing for space. This is stuff that it gets built up there, and it's primarily meant to stay up there, right? So, whether you're building a station or a satellite, Varda focuses on a very different camp of space manufacturing, which is what we call Space manufacturing for Earth. So, all of the materials that we're producing. We only actually bring them back down for terrestrial use cases and terrestrial customers.

Luke: To understand what they plan to produce, Delian first reviewed some physics necessary to understand microgravity manufacturing.

Delian: You know, if you have a desk in front of you, uh you put a candle on it and you light that candle.

Hot air rises, right? So, the candle lights, you put your hand above it and you feel the hot air from the candle, if you put your hand below the candle, you actually don't feel that much heat.

That actually creates what's known as a conductive current, So the hot air, because it has more kinetic energy, it's actually less dense and so that's why it's floating up to the you know top, versus you know cold air is actually more dense because it has less kinetic energy uh and so you create this convective current, where now cold air basically gets pushed upwards as the hot air basically you know moves above it. And this is effectively what actually keeps the candle going.

Now let's take that same experiment and let's run it on the ISS. Right so we've got a desk we light a candle on it, what happens? Hot air rises, but rises implies some intuition of gravity, right? But when there's no gravity, there is no separation of densities of the air. So, instead what happens is you light that candle, the thermal energy being generated by that candle actually very slowly diffuses outwards in a much more controlled way than when the candle is somewhat chaotically pushing the hot air, very rapidly upwards.

Now what actually happens on the ISS if you run this experiment, is actually the candle basically, flames out, after a few seconds because it actually runs out of oxygen around it because it turns out that convective current, down here on earth is with constantly actually resupplying the candle with new oxygen.

Luke: There are production processes here on Earth where you need to heat liquids, or gasses with different densities, and having a more controlled convective current could mean easier production. There are a few examples that Varda wants to test.

Delian: Let's start with the first one, fiber optics. Fiber optics is basically just a very thin glass that you use to communicate. This has probably been the most you know well-studied uh material, both on you know Skylab and the ISS.

Fiber today, largely on earth is entirely made of silica. We actually use it for a wide variety of things. Semiconductors, fiber optics.

However, silica does have some fundamental intrinsic limitations on basically how foggy the glass can be.

Luke: And foggy glass equals poorer performance. Making fiber optics here on Earth can introduce that fog.

Delian: You take a big piece of glass, melt it down, during that melting process, that exact thing that happened with the candle happens in the actual glass. You start to heat it up, but because this glass is made of a couple of different elements, basically the lighter ones float to the top, the heavier ones you know go to the bottom and that sort of entropy or chaotic environment eventually mixes these types of elements up together and that crystal effectively acts as like a foggy point.

Luke: But run the experiment in space, and the result is different!

Delian: Because there's no gravity, you don't have that convective current. And so, the elements aren't moving around, and so because of that, the glass stays much clearer and you have much higher performing fiber optics.

Luke: And another example: biopharmaceuticals.

Delian: So, let's say for example, an experiment that you wanted to run, required, let's say balsamic vinaigrette and olive oil in a beaker, and you needed those to be perfectly homogenous for two hours in order for like the drug to form, uh on earth effectively

impossible right if you do balsamic oil and vinaigrette, same thing happens it filters, the heavier elements at the bottom and the lighter ones, the top. Versus again, on the ISS you can mix together balsamic oil and vinaigrette. It actually stays perfectly together, which by the way, might make salads a little bit tastier, you know, on the ISS, although, salads and vinaigrette, are a little bit hard to, uh, to deal with in 0G.

Luke: The same analogy applies to biopharmaceuticals.

Delian: Probably the best practical example is our Merck, took, uh, this monoclonal antibody chemotherapy drug known as Keytruda. It's actually their blockbuster drug right now highest revenue performer. When they manufacture it down here on earth, it basically forms again, similar to the fiber optics, these really large crystalline structures, because the molecules during the actual sort of chemical process, due to the heat are moving around a lot.

They ran that same process on the ISS got much smaller crystalline structures. Now, why does that matter? With large crystals It doesn't actually, get diffused in your body and your blood. It's not very soluble. And so, what ends up happening is you actually need to take like a 12-hour intravenous of the drug. As well as a small amount of acid in the solution to actually break down those large crystals, it has a particularly painful, clinical patient experience. Versus if you take that same drug that was manufactured on the ISS, that has much smaller crystalline structures. Instead, it turns into a two-minute injectable.

Luke: These are just 2 examples of what's possible with microgravity production. Delian says Varda is taking well-proven science, scaling it up, and offering it to their customers. But taking this idea from theory to practice is a big step.

Delian: In order to produce materials, you know at scale at cheap unit economics, there's two things that need to be possible. The first is humans can't be involved in any part of the process.

Luke: That's because it takes a lot of effort and money to keep people alive in space, so Varda's factories will operate without human beings.

Delian: To as much as possible rely on low-cost pre-existing commercial supply chains. So, how do we at Varda actually, operate with those two axioms? Well, we rely on Falcon nine, rideshares, as well as eventually ideally, you know, starship. These are now an extremely well-proven vehicles.

Luke: So effectively they're piggybacking the materials they need for production and the self-assembling factory on a Falcon 9 to get into space.

Delian: You know, book a flight up to orbit is definitely more difficult than calling an Uber. But it is no longer this, like, you know, multi-year long government contracting process at this point.

Luke: And that's an important point for commercial opportunities. A lot of the key infrastructure for the space economy has been built and is continuing to be scaled which means that teams like Varda just need to contract services to help lift the project off the ground.

Delian: Like, did anybody ask you if Airbnb was making its own data centers? absolutely not. Why the hell would I like make the hundred and seventh, rocket company?

I have a hundred different vendors, obviously SpaceX and rocket lab and, relativity, Astro, etc. being obviously the primary players, but there's a lot of long tail that can offer me rides up to orbit. And so why would I try to, do that myself when I can, use this, now relatively, commoditized, service.

So, one we rely on that part of the commercial supply chain. So, that allows us to get to space.

Luke: The next part is the actual factory!

Delian: The ultimate solution is this uh, three modules spacecraft. The first module is just like everything that you need to operate in space. What's known as like a satellite bus basically, solar panels that give you power a radio that allows you to communicate down to earth.

Second module is the sort of like space factory that comes fully assembled from the ground. So that thing has all the equipment that it needs, the sensors that it needs etc. To execute the fabrication process in space.

As well as all the raw materials onboard. The factory basically comes pre-assembled with all the materials. All that it's waiting for is like hey, get me up to space. And then I effectively, light the candle, that I sat off the manufacturing process that requires the, you know, microgravity.

And then the third module is a small-scale re-entry pod, basically, something that can survive the difficult environment of reentering from space into the earth atmosphere, and basically keep the materials safe inside.

Luke: It might sound like science fiction but they're working off what's been done before.

Delian: It's just like the integration of all of them and doing it fully independent of the ISS. That's the particularly heretical part of it.

Luke: Varda's first launch will happen in March of next year.

Delian: The entire sort of, spacecraft or factory, will be in orbit for about you know a month, maybe month and a half, and then it will reenter through the atmosphere and actually land ideally in the you know, Utah desert. That initial um, satellite system in total will be about 300 kilograms.

Luke: Similar to a standard office desk. Delian thinks of it as a demonstration system.

Delian: We will then fly every six months, uh roughly a similarly sized spacecraft. We'll basically start to do larger and larger amounts of production, and only ever so slightly increasing you know the total size of the spacecraft.

Luke: But the hardest part is the reentry.

Delian: If you've ever watched, you know the Tom Hanks, like Apollo 11 film, like the you know scariest scene in that film is like that reentry process.

Apollo 13 video: Gentleman, it's been a privilege fine with you.

Luke: It's actually Apollo 13, the 1995 film, but you get the idea.

Delian: Entire vehicle shaking, you've got heat going up, all around you. It turns out, you know whether a human or a fiber optic, re-entry is still scary. You're generating, surface temperatures on the vehicle that are equivalent to like the surface of the sun.

Luke: But Varda's production line doesn't need human rated reentry standards, so they are using venture capital to develop their own reentry capsule that will bring the goods back to Earth.

Delian: Reentry is definitely not a problem to be you know, scoffed at. But you know our CEO amongst many of the senior leaders at Varda. Effectively all come from the crew and cargo dragon project at space X and have experience in this very particular field.

Luke: While there is potential, Tess Hatch, the partner at Bessemer, brings us back to down to earth by explaining some of the challenges Varda and others will face.

Tess: Space still is expensive to get up and get back. So, the pessimistic case is how do these unit economics work. And who's going to pay that much more?

As exciting as the technology is as exciting as the potential and the vision and the mission is, I think it's important for deep tech companies to remember at least if they're venture backed, which we look for hockey stick growth in a very short period of time and we only back 2% of businesses because of this rocket ship growth that we have a fiduciary duty to our limited partners to return. Uh, Varda and deep tech companies need to remember that they're like a business and need to make revenue very quickly.

ACT 3

Luke: My colleague at Cambridge Associates Alex Readey, thinks this is where venture capital has an important role to play.

Alex Readey: We can invest in new innovation that might take a decade to come to fruition.

We're not looking for quick, overnight hits. that's happened a lot in recent years where a lot of venture capital funds seem to have been making money overnight. But, we really want to find the long-term enduring innovations that will make a difference over many years and we're patient and willing to wait.

That's the beauty of the endowment model and these institutions that can be very patient capital. Don't need to follow the herd, don't need to run away the moment things get hard. It really is a competitive advantage.

Luke: An example of this was when investors pulled back from venture capital after the .com blow-up in 2001.

Alex: Those who stuck with venture capital and back to new managers, they really, got the fruit of those seeds planted or after the global financial crisis, things really started to come together for venture capital. But if you had just looked at the short-term returns in say 2005 or 2006-7, you would have said, why would I ever invest in venture capital these returns are horrible. Look back to those types of situations where we held steady and show how the long-term perspective and the staying power, comes to fruition very well.

Luke: How would you think about talking to a client that was maybe considering an investment in a space company? Like how do you even, begin to set up kind of the highlights that considerations are pros and cons of such a literally complicated.

Alex: The key is thinking about how that company will benefit people on earth. And we've seen really incredible innovation on earth because of the low-cost space services. The private sector has provided. So, the private sector has been able to do what the government hasn't been able to do in a much longer time.

Private sector is very quickly, got us technologies that were thought to be impossible. I think the realized results and, seeing how much progress has been made in such a short time speaks for itself. But at the end of the day, we trust the venture capital firm, backing the company and rely on that relationship and their due diligence, to continue to co-invest or back individual company.

Luke: And an investment in a space-based company can have a myriad of benefits for us on earth.

Alex: We've seen, investments in space help us measure things on earth, much better. If you can take a picture of every inch of the earth, every five minutes, then you can track, economic activity in places that don't want to share that data.

You can track deforestation, coral reef health, movements in war. So, these tools are very powerful for life on earth and provide data that had been completely inaccessible before.

Luke: Do you find yourself, with some of the companies in such an early stage of development or ideas or themes, how do you balance like unbridled optimism and the like, oh, that's so cool with the kind of maybe cynicism that we naturally sometimes have to have

about like, well nobody's going to be launching reusable rockets into space and landing them, without people on, pads in the ocean. Like how do you try to balance that stuff in your own mind as you think about investing?

Alex: This is why I like early stage investing in venture capital because you get a much larger share of the company for a much cheaper price than you do at the later stage. And back to that, long-term focus. So, we can back a company and its very early days. And then wait, it could be a long time, 15 years before it comes to fruition.

So, when you're investing at the early stage, you're not paying those nosebleed valuations for an idea that might not work. That's been a key tenant to the way a lot of our institutions build venture capital portfolios.

Lately, we've seen the opposite where so much money has flooded in at the late stage, hoping for a one-year turnaround, between when they invest in, when the exit will happen.

And that's not our mentality. We like to invest when the company is cheaper. And we are seeing a lot of the excesses in the late-stage venture capital market get worked out. It's still too early to tell the downturn of the public markets. It's TBD for how it's going to affect the private markets at this point, because so much capital has been raised. But, there will likely be some difficulties at those, mega billion dollar efforts that have been raised that have been invested so quickly.

Luke: In five years, will there be more venture capital funding for space than there is today or less?

Alex: More. Absolutely more.

Luke: Delian says none of the work happening today would be possible without NASA and the ISS. And NASA's supportive of what Varda is trying to accomplish.

Delian: The NASA Ames center, actually, transferred some very interesting heat shield technology to us so that we can use it, in our re-entry vehicle.

I've seen great support from NASA is seeing Varda as this sort of transition path from ISS doing research. And now that research is actually being brought to market finally, rather than just, papers being published about the capabilities of these, various, materials in microgravity.

Luke: And while NASA, other countries' space programs, and hundreds of space-related companies continue to work towards building the new space economy, younger generations continue to look up and wonder.

Presley: Space is so far away and there's still all these things we don't know about space.

Luke: Presley and Krista again!

Presley: I wonder if there's another planet out there with a little girl.

Krista: Like you?

Presley: uhmmm.

Krista: you think she's thinking about you?

Presley: Yeah. Thinking about us! If there's another planet out there with other people.

Krista: Do you think there is?

Presley: Yes.

Krista: Do you think we might find it someday?

Presley: Yeah.

Krista: What do you think we would do if we found another planet with life on it?

Presley: Be so, so, so, so, happy, and throw a party. And there will be millions and millions and millions of people.

Luke: If you want to learn more about the space economy or venture capital, please visit us at cambridgeassociates dot com slash unseen upside or check out the show notes. Stay tuned for more upcoming episodes and if you like what you're hearing, leave us a review and tell your friends and colleagues.

Given the opportunity would you jump on a ship and go into space?

Alex: No too carbon intensive.

Delian: No earlier than 2027, no later than 2031

Tess: Oh, my goodness. Blue origin, SpaceX, Virgin galactic, please take me for free. I will do you so much PR.

Alex: God blessed the explorers who are pushing the envelope there.

Luke: At Cambridge Associates, our podcast team is led by me, Luke Charest, Hillary Ribaudo, and Brittany Thurman.

From PRX Productions, Sandra Lopez-Monsalve is our producer, Ari Daniel is our editor and Courtney Fleurantin [FLOOR-AN-TEEN] is our associate producer. This episode was mixed by Terence Bernardo. The executive producer of PRX Productions is Jocelyn Gonzales.

Before you go, one of my colleagues has an important message about the contents of this podcast.

[DISCLOSURE]

Nancy: Hello, this is Nancy Ni from Cambridge associates, Boston office.

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Thank you.