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Space Technology

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Hanish Patel:
I am Hanish Patel, and this is *User Friendly*, the show where we explore emerging trends in tech, media, and telecom, and how they impact business, operations, and the world around you. To use a famous opening, "Space: The final frontier." And although space still seems far away from many, the last few years have proven that it's much closer than we thought. Different developments in space technology have broadened the way that we interact with the great unknown entirely. But what does that mean for us here on Earth? Here today to discuss the positive impact that technology has used in space and down here on Earth, from satellites to renewable energy, is Bosco Lai, co-founder and CEO of the Little Place Labs, and Lars Cromley, leader and technology fellow in the Cloud Strategic Growth offering at Deloitte Consulting. Bosco and Lars, thank you for joining me today. I look forward to a great conversation.

Bosco Lai:
Great. Thanks for having us.

Lars Cromley:
Thank you.

Hanish Patel:
OK, so, let's get into this exciting and fascinating episode. Space is such a big topic. Bosco, I'd like to begin by asking you to give us an overview of why space is becoming increasingly important here on Earth.

Bosco Lai:
I think people don't really realize that

space has always been a part of our lives, and I'm talking about daily lives. Before you even get out of the door, for most people, we use space technology in ways that we don't realize. For example, using connectivity through your phone to many different things out there. GPS, for example, navigating through your roads; weather forecast—checking out whether it's a rainy day or a sunny day. So, on average, we use a lot of space technology in our lives. And space is not really just about big rockets and astronauts, although those are really, really important aspects of space. But there are many different ways that we can use space.

The reason why we are getting into what we call this new space era is a few factors. For example, rockets are now much cheaper to launch, as we have heard, for example, in the last few years, reusable rockets. We now don't need to build rockets and pay for that infrastructure to be used just one time. The satellite infrastructure [is] getting a lot more diverse. And right now, there's a whole spectrum of satellites that are, let's say, more expensive and more hard to maintain, to smaller satellites up there that [are] much cheaper to launch, much cheaper to replace, opening up to new opportunities. And then there's really the ambition of national programs. So, now, we are hearing about not just NASA but, for example, other space agencies in other countries that are very, very ambitious in opening up their economy to really look into what space can do for them—not just from a national security point of view, but also from a commercial side. How can we use space technology to open up commercial opportunities? So, there [are] a lot of technical things that are changing that really enable this new space era to come in. But more importantly, I would say, is the mindset change, the commercial integration with the government work. And now, there's a mindset to defense and many different aspects to think about, hey, if you can buy this, if you can loop in commercial players to come in and develop technologies quicker, do it, collaborate. Don't just build in a vertical integrated fashion. So, there's a lot of collaboration between the commercial side and the government side, which is enabling and fueling the buildup of the new space era.

Hanish Patel:
Building off that, think about everything Bosco just mentioned around that mindset change and real kind of space era that we're in. Can [you] speak more about how space connects to technology and how that technology's really being used both here on Earth and in space to really bring that kind of space closer to home, so to speak?

Lars Cromley:
I think everything that Bosco said is spot on. And I think going into this era, space has united us as a people since the beginning of time. We all stare at the same sky, the same stars. We all live our lives beneath this. And I think when we think about how does that technology relate to space, what are the things that are going on? So much of this is invisible. We don't realize exactly what's happening. But if we look at agriculture, environmental monitoring, urban planning and real estate, transportation, logistics, telecommunications, the energy sector, all of these things benefit from space-based technology and data. So, I mentioned agriculture, precision farming, satellites are providing data from monitoring crop health, soil quality, looking at weather patterns, enabling farmers to optimize planning, irrigation, and harvesting. And you have yield prediction, which is really important in the insurance industry of understanding how you analyze predicting crop yields more accurately based on a combination of factors. We are doing urban planning, land use analysis, property evaluation.

There's so many different facets of how space-based technology impacts our lives. And if we get even closer to that, this is like a trend that's been continuing over a long period of time. The CMOS sensor that is in every single smartphone is a byproduct of space-based research and space exploration. The protein-rich algae compound that's found in like 80% of baby

formula was developed by Martin Marietta during the initial Apollo missions. And so, there's things that have permeated all aspects of our lives, and we don't technically see it so clearly, but it's there.

If you look at the beginning of this and where these things originate from, it's based in our space-based research. And so, I think as Bosco was talking about, this kind of new space age, there's really, I think, four kind of value streams that are being realized. The most common one that I think is the most broadly applicable is space-based research, which is where we get these really big things, like the GPS constellation and stuff like that. But then you have space launch and logistics, and this is a whole industry that's cropping up. And then you have space-based data and applications, which is probably the most far reaching. And then you have direct consumer businesses, which is where we start talking about space tours and things like that. So, things are getting really exciting, and the technology that's being developed is getting pushed further and further ahead. And now, even when we're thinking about how do we do some of these things and how we're delivering it right now, those things are constantly improving. So, it's a really exciting time for the space industry as a whole.

Hanish Patel:
I want to continue on the train of where you are going, particularly citing so many different aspects that, in all fairness, if you're not close to it, you'd never imagine was related to space or what's taking place in space, or folks out there on satellites, etc., whether they're on there or they're remotely operated. One area, obviously most people tend to think about space, beyond the more recent travel aspects, is just communications and the ability of satellites to further enable the communications industry. So, sticking with that, how would you say [the] space industry is truly innovating and helping progress [the] telecommunications market overall?

Bosco Lai:
Great question, and I think it's very relatable to everyone. Again, if we rewind back 10 years ago, what does telecommunication even mean to everyone? People think about, well, calling your friends, calling your family. Nowadays, it means a lot more. We pick up a phone, we would watch something , it's not even low resolution. Now, we talk about high resolution. Every single one of that interaction requires data being transferred from one spot to another through satellites. And so, when we look at what are the improvements and innovations that are happening, one is definitely more satellites—and it's not just about the number of satellites, but how powerful are these satellites. So, if you look at each one of these satellites, or [what] we call constellation of satellites, which just means a fleet of satellites, we now see more advanced computing on the satellite. What that means is if you rewind back again a few years, the computing power on that satellite is probably less powerful than your phone. It's probably even less powerful than your watch. Now, that's changing.

More computing power and capability and even storage are getting better on the satellites, which means that instead of just being an asset that is collecting data, there's a lot of processing information, what we call tipping and queuing other assets that can happen on these assets which enable hybrid constellation or hybrid satellites. Now, you can have one set of satellites working with another set of satellites, even if they are not of the same specification or they are of different company owners and operators. So, now, we really see each of these satellites being more powerful, and they can work together with other satellites in space to create that more efficient communication, to getting that data from one place to another. And we talk about also laser communication. Laser communication is going to be dramatically improved, in terms of bandwidth and speed, for how data is being transmitted—not just from space to ground, but really even between assets in space—a hundred times, a thousand times, faster than what we are seeing today. So, again, all these technologies that are coming through is really going to dramatically increase the power of these assets in space.

And now, we look back on ground too. One thing that we really need when talking about telecommunication and transmitting data is ground station. So, all these gigantic dishes that people see, we need that to get the information back down from space to ground. And now, you have a lot of players that are building infrastructure on the ground that gets more coverage so that a satellite flying by in space, they can get in range of that ground station much easier and much quicker. So, a lot of this infrastructure is being built out based on the demand in the market and also better pricing model. It's really increasing, especially in places where they're more remote and historically hard to get to. Now, that's changing.

We are seeing some real partnerships, too. For example, T-Mobile and Starlink joining forces to really eliminate cellular dead zones. Historically, these people can't even get access or signal on their phones. You have Verizon teaming up with Amazon's Kuiper to provide global 5G coverage. And also on the SOS side, Apple kind of communicating or partnering with Globalstar to really enable that SOS satellite communications. So, again, it's not just a technology play in space and on ground, but also having these big companies and businesses getting together to really look at, "Hey, how can we make things better from a telecommunication point of view from space for the ground users?"

Hanish Patel:
So, I want to dig in a bit further on something you just mentioned around partnerships, and also earlier around kind of national programs. Think about the two of those. You've got some private-public type of partnerships taking place, like SpaceX and NASA, to really kind of provide those low-Earth orbit satellite environments. If we look at that as one example right there, how can the commercial market continue to build upon those partnerships that are starting to take place at a private and public level as well?

Lars Cromley:
There's several companies that are working through the commercial payload services

to provide services to the ISS. But we know that the ISS has been there for the better part of two decades, and it's getting a little old. NASA has expressed interest in going beyond that with our Artemis missions to the lunar surface. And even in the next month now, we're going to see the first commercial payload being sent to the lunar South Pole to do some prospecting and looking at lunar ice. And so, right now, I think the way we look at it is NASA has what most people would consider a tremendous budget of about $26.6 billion—and that number is probably a little off, but a roundabout that number. And the thing is that even as cheap as launch is getting and the access to space is coming down, there's entirely too much to do for NASA be able to afford on its own. And there's a lot of really interesting things that can be done in microgravity environments in terms of like things like life sciences, we talked a little bit about prospecting energy manufacturing. There's a lot of new industries and a lot of new opportunities for industries that I would say are traditionally not space-based businesses.

So, the way we think about it is space is a mission, space is a business, and space is a growth opportunity. A lot of these companies have a growth opportunity in space. And what we're trying to do, particularly with what we do within the GRAVITY Challenge that we [Deloitte] run, is try to show where that connection to that technology is for the companies that have not been thinking of space. And when we think about this, you still need the expertise to get there, you still need the launch services, you still need mission design. There's a whole bunch of things that you need to get there, but that barrier to entry is becoming lower and lower as increased launch cadence has happened.

That partnership between commercial entities that are nontraditional space companies is creating an opportunity for partnership, for learning, and for joint research to be conducted. There's a number of companies that are providing services right now, where you can do experimentation and microgravity settings and things like perfect insulin can be created in microgravity or perfect fiber optic cables. There's certain cultures within medicines that only bond because the surface tension on Earth is so low, and so gravity's working against it. So it can only bond in a microgravity environment.

These things are becoming possibilities and becoming viable because the cost to get to orbit is becoming a lot cheaper. As we look at that, I think that's really where we start seeing big opportunities for partnerships in the commercial, civil, and even defense sectors to start working together to further their missions and their goals.

Bosco Lai:
Yeah, I just kind of want to add onto that. GRAVITY Challenge is absolutely a good reminder. Our company, Little Place Labs, actually started from that challenge. And the reason is because GRAVITY Challenge connects the end user that can benefit from space technology and innovators like us to go, "Hey, let's solve a problem," because we all know a great technology is only good and worthwhile developing if there is a good demand. So, forums like this where it connects the dots from different perspectives is great. But one thing to highlight is, too, when we talk about what government is actually doing to promote space technology, especially on the commercial side, is all these programs. So, we see quite a lot of opportunities that are posted by agencies, like space agencies, that come out and say, "Hey, we're going to give you some budget to support you to do R&D of certain technologies depending on what area we are in." So, that's great. We got some funding to do some early R&D that hopefully can get somewhere to a material level that it can excite the commercial end users. But now, we are seeing agency taking the next step. We don't just want to fund R&D, but we really want to take the next step in connecting the end result of the R&D to an end user.

So, now, we are also seeing agencies that come out and put in the secondary program as to, hey, if you can actually find an end user that could be benefiting from the technology that you're building and we can get on the table and talk about a pilot that we can run together with them, then they're actually going to fund the pilot for the commercial end user. Which is fantastic because one is that, hey, we eliminate the uncertainty of the end user. Let's say if an end user has not used space technology in their businesses before. They want some validation, and obviously talking to early technology companies or early-stage companies, that certainty or that trust doesn't really come in until you actually have proven it, let's say through a pilot. So, if now, the agencies [are] coming and say, "I'm going to fund that pilot as long as you guys can come and connect the dots for us and make sure that things are done right and throughout the time of the pilot," then that is a direct way to turn into a commercial contract that is viable for the long run for the company. So, again, we are seeing a lot of support programs from the agencies and governments and now they're taking the next step to make it even better to help companies to commercialize, not just at the R&D level.

Hanish Patel:
So, with that in mind, who's driving the standards or the regulations? Is that again on the agencies at a national level or [is] commercial also helping set those standards going forward?

Bosco Lai:
It's different. It depends on what we're talking about. Obviously, space has its own complexity and uncertainty because space is not owned by anyone. There's a treaty that was signed decades ago that provides a general framework on what people can do and not do, but for the most part, the implementation—and we get to the nitty-gritty details of what can someone do and not do—really now falls back to the national level. So, it really depends. But a lot of this is still kind of ongoing because, again, you have an area where the use cases are opening up, the technologies [are] being developed at a very, very great speed. So, you kind of have a little bit of a catch-up game to play

from a regulation and compliance level. And also, you can't really just look at [what] one country is doing. If you put on too much regulation too fast, then you kind of disadvantage the companies that are within the jurisdiction versus what others are doing. So, it's very interesting. It's kind of a similar phenomena that we are seeing with AI. We all know that there are some things that need to be put in place for AI, but who is going to do that first and what's the first draft going to look like?

Hanish Patel:
Got it. I appreciate that. And then you mentioned gravity and then, Lars, you were talking about microgravity. For the benefit of our listeners, could you dig in a bit more about microgravity itself and some of the benefits that you started to touch upon earlier?

Lars Cromley:
Yeah. So, we typically refer to microgravity, as it's kind of a misnomer as "zero gravity." From a physics standpoint, you never really escape gravity. You're always under some influence of it. When you are in orbit, if you're in LEO [low-Earth orbit]—so, say we're in where the International Space Station is, which is about 235 miles above Earth, what you're essentially doing is just continuously falling. And so, you have to get to a speed of about 17,000 miles an hour to continue basically floating and falling around the Earth as gravity continues to pull you around that. And so, in the sense, you can't really feel gravity because you're continuously falling. It's kind of like if you've ever been on a plane—most people have been on an airplane at this point—but if you go up and you see it like when it pitches up and you kind of feel that feeling where your stomach kind of feels like it's got butterflies, what you're feeling is that reaction to that change in gravity. And so, you can kind of simulate this with something called a parabolic flight, which is basically where a flight does something that it's really not supposed to do. It's where it pitches up really sharply and then climbs, and then at the top of it, the apex of the parabola, it goes down. And then that's when you experience this weightlessness. In reaction, what you're actually doing is falling. But that microgravity environment is really important when we start thinking about how we can create things that are incredibly straight because it's not feeling the direct impact of gravity as it is on Earth. And so, some of these manufacturing processes for creating things that are incredibly sensitive, you can create a much higher quality because it's something that you don't necessarily have to account for or control for on orbit.

Hanish Patel:
I appreciate that. Thank you. I was just geeking out as you were talking through and describing that. So, I'm actually going to try and bring us back down to ground level, from high up above, from the atmosphere. What are some of those technologies that are actually being developed that are helping grow the space market overall? So, kind of what we're doing back here on Earth to really change what's going on above?

Bosco Lai:
Let's start with not talking about technology, but, again, going back to one of the points that I made earlier: It's about education. I actually just came back from COP28 in Dubai and was fortunate enough to share my thoughts on two panels. And the theme is quite general: How do we use space technology to take climate action? And a lot of the feedback and a lot of the conversation that went after that was really smaller nations, or areas and people and stakeholders, were traditionally at a disadvantage. Because, let's put it this way, if we are not using space-based solutions, then the alternative is usually ground-based solutions. And if you have to monitor something using ground-based solution, you actually have to put devices and install instruments and whatnot on ground. Usually that takes a lot of money and a lot of time. And if you are one of those smaller nations or more disadvantaged areas, then you can't really do that.

So, historically, there has been a disadvantage of them being able to utilize technologies that are ground-based, that are available in other parts of the world. And so, now, when we look at space, we all know that space doesn't have boundaries. Like you launch a satellite up there and you fly in orbit, you can look at anything, depending on the use cases. So, it's really about how do we educate everyone and opening up that dialogue to go, hey, what space can do for everyone and help traditionally disadvantaged countries or nations or groups to really leapfrog that.

For example, now we can use satellite to monitor the conditions of roads and even do optimization to go, "Hey, this is the right place to put a highway in, this is the right way to put infrastructure in." And if we can use that to help leapfrog some of these traditionally disadvantaged groups, it's amazing, the infrastructure's already up there, the satellite's been paid for. So, it's just really about collaboration and educating both sides of the equation. But from a technology side, we talk about cheaper launches, more frequent launches. I think that's going to continue. More advanced computing on board is very, very needed because we're collecting a lot of data up in space—gigabytes and terabytes of data every single day. We need to have more powerful computing, more sophisticated computing, to help us again sort out and prioritize what do we actually need and what we don't. Otherwise, it would just become a big, big data problem. And then we are already seeing a lot of other technology, for example, laser communication that I talked about, which enables much quicker communication between assets in space and also space to ground. But one thing that I also want to highlight here is while there's a lot of advancement in space, there's a lot of good technologies, we need to better monitor all these activities that are happening in space.

Listeners here may have heard about the term ***space debris, or space junk, or space situation or awareness***. We have launched almost 10,000 satellites up in space historically, and probably half of them are no longer useful. But it doesn't mean that we can tick them out. Like if a satellite's no longer useful or past its lifetime, what do we do with it? We need to de-orbit it, bring it back to ground, or pull that out from the orbit. That doesn't happen automatically, and it's still a technology where it's being developed today to effectively remove unnecessary assets from space. So, I think that side where we call space debris, technology or space situational awareness is a big, big area for us to put more R&D and implementation and budget on. Otherwise, you are just going to run into issues in space where things [are] crashing into each other, and it's not good for anyone.

Hanish Patel:
So, I want to stick with that. And you mentioned COP28 as well. Climate sustainability focus for so many. And earlier right up front you touched upon things like reusable rockets. So, I'd love to dig in a bit more around some of those technologies that are taking place to really prevent some of the potential negative impact that it can have on Earth's overall ecosystems. I would love to get your thoughts on that.

Bosco Lai:
Yeah. I mean, there's a lot of use cases where we're using space tech to take climate action. A simple example is on the energy side—renewable assets, renewable energy. We heard from COP28 that we want to move away from fossil fuels, we want to build more renewable assets and then we get to bad actors that lead to concerns about greenwashing, which is people getting funding and money and budget to build assets where it's not actually doing or making the climate impact that it's saying it's going to make.

So, I'll give you one example. If we want to build more renewable projects—let's say you want to build one renewable project—how can you use space technology to help you? One is, well, first you need to find a place to build it. So, let's say if you're building a wind farm, or a solar panel, or solar asset, you need to find the best plot of land and instead of going onto ground and onto site and just look at every site, you can actually use space data. You can use space data to tell you which area provides you with the best what we call "solar irradiance." So, in other words, which part of the land is going to be sunshine all the time so that you can get the best yield out of a solar panel. Then, let's say you have identified that plot of land, you'll go to the bank and say, "Can you finance this asset?" Well, the banker doesn't want to have to drive out there and take a look at the plot of land. Or they have to monitor that, hey, you're actually building the asset and monitor progress. The bank can do that by using satellite data to go, "OK, this quarter, you've done that. This quarter, you've done what you're supposed to do." And then ongoing monitoring of performance. Is it actually yielding the impact that we are looking for so that you can turn that into tax credit or other kinds of credit to make sure that the money that's being put in? It's actually generating the environmental impact that everyone is looking for.

So, it can really eliminate some of the concerns about greenwashing and really validate the impact of all these assets and progress that we make on ground. But there are other use cases, too. For example, detecting illegal deforestation.
In the mining industry, for example, we now have what we call multi-spectral sensors that can really look at—let's say if you're looking for a particular mineral or material that you are trying to mine from the ground, instead of just right away digging and digging and digging and then testing, you can now actually use what we call multi-spectral sensors to take a picture of it. And the result will tell you whether the mineral and the material that you're looking for is actually on ground befoxsdre you spend time in digging. So, that would very well help the efficiency of even traditional—very, very traditional—industries.

And then there's disaster response, right? Now, instead of, for example, wildfires—it's a big, big problem in Australia, in California, and around the world—how do we actually effectively monitor hundreds and hundreds of miles of wild forest? You have drones, you have ground-based cameras, but they're not efficient. We're talking about hundreds and hundreds of miles of wild forest. What if satellites can actually look at hundreds of miles of area and be able to tell us whether there is a fire or even a plume of smoke very, very quickly. So, there's a lot of use cases that I can think of, like even maritime surveillance. Again, looking for illegal fishing activities, which we have one project looking for illegal fishing activities around the coast of Thailand. It's a big problem in that area, and there's no good way other than really using satellite and satellite data to monitor. So, it's limitless. It really goes back to, again, do we have a forum and open dialogue to connect the demand and parties that are suffering from this problem to innovators, to the government, to really form that collaboration.

Lars Cromley:
And real quick, Hanish, I wanted to touch on a couple of things that Bosco talked about—these kind of past two. As technology continues to advance—and education's a huge part of it—but understanding how we can apply those technologies in new ways and what those new technologies allow us to do and how we rethink space missions. So, Bosco mentioned reusable rockets, we've talked about that a little bit, but even more important than that is how much mass we're actually able to get to orbit. And this is something that's changing pretty rapidly right now. And if we come to this future where we have an easy way to get a large amount of mass to orbit, there's a couple of problems that could arise from space situational awareness. We're putting too much stuff up there potentially. But some of the things it allows us to start thinking about is making more decisions around using commoditized hardware, which is easier to create, easier to manufacture, and cheaper to produce, so that we can have things in multi-orbits with different types of technology that's much cheaper to get up there and much cheaper to produce. So, it even brings that cost of research and the cost of mission down even further.

But we talk about having more compute in orbit. What does that do for us? It allows us to do some really amazing things. Right now, we talked about ground stations, traditional assets that have been deployed in orbit prior to the last 10 years are typically terrestrial bound, which means they can only communicate with the ground station. But now, if you have more compute power, more storage, more memory, and you're able to put that in orbit, what it essentially allows you to do is to simulate a ground station. And if you can simulate that ground station, what you can start doing is creating new opportunities for the ways that traditional legacy assets that are still in orbit can communicate and augment their mission. So, it means that we don't necessarily have to put more stuff up there to get more functionality. We're already using the things that we have in a smarter way and repurposing and re-creating how they serve the general public.

I think the other thing is, if we start thinking about more of the technology and what's kind of causing this, part of the big problem with the compute that's there—and Bosco talked about this a little bit around the compute power—was like your phone has more compute power than a lot of the computers on orbit. But the reason for that is because a lot of it has to deal with cosmic radiation. It's an extreme environment operating in space. And so, the larger your transistor gates, which means the larger the transistors, the less likely they are for interference. The more compute that you want to do, you have to have smaller transistors, which are more prone to interference. So it creates issues with running computers in space or on other plants and things like that. And because of the advancements in technologies, particularly over the last decade, we're finding better ways to operate this technology, which means there's a greater opportunity for us to do things like we were just talking about around kind of mimicking ground stations and augmenting the existing assets that are already there.

The other thing is because we are creating new types of technology like laser communication that allows us to do something with what Bosco was talking about around constellations. Essentially no orbit is perfect at any given mission. So, what we're able to do now is we're able to create constellations that can be inserted in multiple orbits. So, lower Earth orbit, middle Earth orbit, and geo orbit—or very high orbits. And what that does it gives us benefits for latency, for bandwidth, better economics, better security, increased reliability and availability so you can get more eyes on where you need to monitor. So, for things like forest fires and agriculture and monitoring things like methane output. So, if you want to be able to see where all this gas is coming from, we can monitor that much more closely and take real action against it.

Hanish Patel:
I'm somewhat pausing, taking in all the advancements in technology and our space as had such a big play back here on Earth and some of the innovations that it's led. I'm going to ask probably a difficult one back to the both of you.

Based on the sheer advancement that's taken place, what kind of innovations can we expect to see, in say, the next three or five years? And if you're feeling really adventurous, even the next 10 years, when it comes to the space technology sector.

Lars Cromley:
I think the one that I'm most excited for, I think, in the near term is just expanding by what we call our land mobility network. And so, this is particularly for like agriculture and being able to have more insights for farmers to know about the state of their crops and how things are going and having connected hardware.

We're already kind of doing this with things like combines and tractors, but having better visibility and data of understanding what and how we're farming, I think to produce more food. At this point now, I think we grow more than enough food to feed the world every single day, but so much of it's ruined in transport. And so, even in smart transport, having this ability to connect anywhere on Earth to a high throughput, high-bandwidth connection, creates some really interesting possibilities for what it does about like logistics and shipping of food. And I think that kind of land mobility network of being able to go directly to space for your connection or piggyback off of a 5G connection or something like that.

In the next three to five years, I think that's something that's going to be much more prevalent. It's going to cut down food waste and food spoil. It's going to allow us to get more things where they need to go, in time.

Bosco Lai:
Yeah, that's a great point. I think a big bucket that I'm going to go to is compute again. Space is still a very restricted environment. So, just to give you an example: If you want to run any, let's say, machine learning applications in space, the restriction in terms of the size of the model or the application, the electricity power that you can consume, it's usually, let's say, a 50th or even a 100th of what is available on ground. And so, to run any meaningful applications or data processing in space, you need much better power supply. You need much power spec in terms of the hardware that is going up. So, I think piggybacking on what we have seen in terms of microprocessors that's being developed for phones, we are seeing the leverage of that technology in space now, we're getting much better processors. And I think the next step is, hey, how can we actually make the other components of the satellite more efficient? For example, more efficient propulsion, more effective solar panels, so that we can carve out more power supply for compute for many different use cases.

The other thing is when we talk about data processing or more compute, we are still talking about it at each satellite level. Let's say on ground today, things are run on cloud. So, you don't necessarily run your compute or require the computer to be sitting on where you're working. In space, it's still very limited to a particular satellite. So, you have to collect the data, you have to run the process all in one spot. But that's about to change.

We are now seeing talks and implementation of data centers in space. And once that's become viable and accessible, that's a game changer. Now, your satellites can be capturing a lot of data, with laser com, it can be sent to these data centers and data centers is where all your compute power is going to be in. And you can run a lot of applications up there and start to generate insights and alerts and even task-and-command to other assets. That would be a game changer. And very, very excitingly, it is already on the road map. I think when you talk about three to five years, definitely we will see at least a workable version up in space. And again, just going back, a lot of the things that we are talking about here, even space and manufacturings and all the work that we are looking at five plus years out requires bigger infrastructure in space. More like the space station. We need a lot more bigger infrastructure like that, which also means that you'll have more humans in space. There'll be humans there, running processes, maintaining the infrastructure and so on. So, the next level of technology that we need to build in is also how can we support human in space? How can we create technologies to monitor those astronauts or humans' well-being in space for a longer period of time that we've seen today. So, it's a fascinating area. I think we could be talking again as a group in three years' time and we could have a completely different view because things have been moving so fast, but it's truly fascinating.

Hanish Patel:
Well, one thing I've got to say is fascinating, such a compelling topic. I'm not going to wait three years before we get the both of you back on here. I mean, this is just such an exciting topic that we've covered here today. And it's clear there's considerable excitement and opportunity for the future of the space sector, both from government and private companies, and from what we've heard from the both of you, just the sheer impact it's made on everyday lives back here on Earth.

It's not just about things that are taking place in the atmosphere, it's about the impact it's making back here on Earth. And again, truly fascinating on how these technologies have developed to explore and regulate space to ultimately improve our life so greatly here on Earth. And certainly, what maybe used to be the realms of science fiction is progressing right before our eyes. And with that, I have to say, Bosco, Lars, thank you ever so much for coming on the pod, providing your expertise and knowledge about such a compelling and exciting topic as space. And as ever to our listeners, happy listening.

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