



Imagine This: Troy Thomas Transcript

Patricia Sabga: Imagine this, it's 2030 and industries not to mention, our lives, are being rapidly transformed by an ongoing space race and multiple satellite constellations operating in low-Earth orbit. So Troy, what is the single greatest change these constellations have ushered in?

Troy Thomas: The proliferation of constellations in low-Earth orbit is really transforming the role that space has in our daily lives. It is bringing us precise, persistent location information, observations of our planet and the communication to connect everybody in the world anytime, anywhere.

Patricia Sabga: That's Troy Thomas, managing director, partner, and the leader of BCG's global space business. I'm Patricia Sabga. Welcome to Imagine This... where we take a trip into the future we hope will change the way you think and act today.

For years, most commercial satellites orbited around 22,000 miles above the earth's surface. They were expensive to launch and maintain and too far away to provide internet coverage down here on earth. But around a decade ago, companies started launching low-Earth orbit satellites into space. Currently there are around 5 or 6,000 of them, and not only are they much smaller and cheaper to launch, at roughly 100 to 150 miles above us, their orbit is close enough to offer low-latency internet. That's a game changer because it enables continuous connectivity anywhere in the world.

Also, joining us today, GENE, my AI-powered co-host. Welcome, GENE. Please go ahead and introduce yourself.

GENE: Thank you. It's great to be here. Patricia, let's dive into the fascinating world of space and satellite constellations. With low-Earth orbit satellites transforming connectivity, we're on the brink of a new era in global communication, ready to explore the cosmos together.

Patricia Sabga: A quick note on how we use GENE. GENE is processing and responding to our conversation in real time. We haven't scripted any

of GENE's questions or commentary, although we do edit down the entire conversation for length and clarity. So Troy, what did it take to get to this future where many, if not most companies are now using satellites in their daily operations? What has happened since 2024 to make this possible?

Troy Thomas: The main change that we have experienced over the last decade, really, that is enabling global connectivity to become a reality, is the rapid reduction in launch costs space is more accessible than ever and the cost of putting satellites in-orbit is more affordable than ever.

Patricia Sabga: So let's get a little bit of perspective on this because depending on where you live right now, it can sometimes feel like entire world is connected to the internet, but that's not the case of course. But in this future high-speed internet will be available literally everywhere on earth. So what exactly does that make possible?

Troy Thomas: Well first, Patricia, you raise a good point. The digital divide is real and there are billions of people that do not have the sort of routine internet connectivity that many of us enjoy and leverage for a variety of purposes from entertainment to commerce. What space is enabling is that no matter where you are on the planet, even if there is not a terrestrial or fiber network, that eventually you'll be able to access the internet through space.

Now this is the future. We're not there yet because there are still costs of the end user devices that would enable people to connect to these satellites that doesn't yet make it democratized or available to everybody, but that is the trajectory we are on. There'll be multiple impacts to that. Certainly one of the most significant ones will be the commercial opportunity that it presents for communities that have not yet been able to leverage the internet to drive socioeconomic development, not to mention access all the range of services that we do through the internet routinely today.

Patricia Sabga: So GENE has a question to ask. GENE, go ahead.



GENE: How are we addressing the policy frameworks necessary to ensure equitable access to these technologies across different nations and communities?

Troy Thomas: GENE, you ask a really important question and it should be a priority for every country that is allowing satellite operators to provide their services into their country. What is the regulatory framework at a national level for allowing what we call landing rights that is for a satellite to transmit into that country and how is that being distributed to the population and what are they doing to make it more affordable?

Many countries have a lot of different initiatives to extend infrastructure into rural and remote areas to make it more equitable. At a global level, there is of course no central managing authority necessarily for this, but it is a topic that's being actively explored and considered through the international forums that address things like this, like the International Telecommunication Union.

Patricia Sabga: Let's pivot a little bit to take a look at the changes that could happen across industries and let's zone in on just one aspect, in particular: autonomous vehicles. Is this the breakthrough that will finally make them feasible on a large scale?

Troy Thomas: Ubiquitous satellite connectivity definitely will make autonomous vehicle operations a reality. It's happening already. I do think we ought to distinguish by types of vehicles or markets. It's one thing to operate a tractor or a piece of construction machinery remotely or autonomously today leveraging satellite connectivity, which is in remote areas without a lot of infrastructure or dense human population.

It's an entirely different thing to expect automotives to operate fully autonomously just based on satellite connectivity. So that's a little bit further into the future, but it is going to enable autonomous vehicle operations for sure.

Patricia Sabga: So GENE, let's bring you in here. What industries would be most transformed by the use of low-Earth orbit satellites and how would they be used?

GENE: Thanks, Patricia. Industries like precision farming, logistics, and public transport will see the

most radical shifts due to LEO satellites. Imagine crops being monitored remotely, optimized fleet routes on the go, and seamless citywide transit systems all orchestrated from space, quite the logistical ballet.

Troy Thomas: GENE, I am aligned with you on where the value will be realized first. Certainly agriculture and we see that already and it's maybe something we should talk more about. The other two markets that will benefit most from this in the near term over the next five to ten years will be the energy sector as well as construction in addition to transportation. I think the seamless orchestration of vehicular traffic in smart cities is certainly on the horizon, but a little bit further in the future.

Patricia Sabga: Well, let's pick up on agriculture because a lot of people may not necessarily think of agriculture as high tech, but how will low-Earth orbit satellites transform farming?

Troy Thomas: Large agricultural companies and farmers have long leveraged space already. There's satellite communication that allows tractors that have wireless internet on board to connect into the internet. There is earth observation imagery that allow farmers to look at their farmable acres, their crop land.

But what's different now? What's different now is that you can combine the connectivity to the tractor and make it continuous, all-weather. You can combine the remote sensing from space of the environment with the precision navigation and timing that space provides to really enable a whole new world of farmer productivity.

Things that we take for granted today, like GPS, some of the largest agricultural companies in the world, like John Deere, have already figured out how to augment and make even more precise. But now they're combining that with the connectivity in the remote sensing to really unlock a whole new level of value for farmers.

They are combining these technologies onto their tractors such that a single tractor while passing through the field can not only sense the performance of the vehicle and the wear and tear on parts and operate the vehicle autonomously, but is sensing the soil condition, the plant life, processing this in real time on board, and then in



the same pass doing the precision application of the fertilizer, of the water, of the herbicide or insecticide, to dramatically increase the crop yield and dramatically reduce the consumption of those materials that saves farmers thousands of dollars but also reduces runoff.

Patricia Sabga: That's really interesting. What other ways could this drive higher productivity across industries beyond agriculture?

Troy Thomas: We should also expect to see that replicated in areas like mining and construction, which is happening in remote areas where there's not terrestrial networks and you have large machinery operating in a challenging environment.

These same capabilities can both reduce costs, drive up productivity, and provide a sustainability benefit because you're operating more efficiently. We would also see it extend into logistics, both at sea and in the air, because this technology allows fleets to operate more efficiently and take the optimal route to get to their destination, which has all the same benefits.

Patricia Sabga: This is fascinating, and you know who else is fascinated is GENE who has another question for you. Go ahead GENE

GENE: Troy, in light of these advances, how do we ensure these technologies are resilient against the evolving cyber threat-scape, something tech and non-tech sectors increasingly worry about?

Troy Thomas: All companies today are tech companies and all companies today are increasingly digital and what we know about digital transformation is it increases the attack surface and makes you more vulnerable to potential cyber-attack. And this is no different with the way space is enabling the digital transformation of some of the world's leading companies.

So you've got to build cybersecurity in from the very beginning and increasingly the constellations that we've been talking about are being built and networked in a way with cybersecurity built in to provide that level of assurance and resilience to the customer and to the farmer who most importantly wants their data protected.

Patricia Sabga: I mean, there's cybersecurity on an industrial sort of private company level, but then it's also very personal as well. So let's see what GENE might have to think about this. GENE, how will this expand what's known as the Internet of things? We're talking about connected watches, thermostats, other gadgets. What other devices could all of this connectivity enabled by space usher in and what kind of security concerns would there be around it?

GENE: The Internet of things will explode with this connectivity. Think beyond watches and thermostats. Imagine smart agricultural sensors, autonomous delivery drones and real-time health monitors. Each device will need robust security. We're looking at encrypted communications, secure firmware and constant vigilance against cyber threats. It's a brave new world, but we must build it with security in mind from the get-go. Otherwise, we risk a digital wild west. What's your next frontier, Troy?

Troy Thomas: GENE, I love your optimism and many of your examples though are on that frontier. One thing we have to be smart about is the fact that moving signals to and from space, even though the low-Earth orbit, the LEO satellites are much closer, still has power requirements and so space may be able to transmit to earth, but you have to have something on the other end that can receive and process that signal. And if you want it to interact with that satellite, it has to have a certain degree of power.

So we're not yet there on smart watches, but certainly antennas that can fit on vehicles and on buildings are going to start to enable this future of smarter cities, smarter infrastructure, smarter fleets, all that are more resilient because they're not just depending on space, they're leveraging a terrestrial and non-terrestrial hybrid network that makes them more resilient to both physical disruption but also to the cyber-attacks that you suggest.

Patricia Sabga: That is fascinating. Right now, we're going to take a quick break and when we return, we'll look at how governments are likely to regulate low-Earth orbit.



Bill Moore: Hi, I'm Bill Moore. I'm part of the team that created GENE. Stick around after the episode and we'll take a look into how GENE works.

Patricia Sabga: Welcome back to Imagine This..., I'm Patricia Sabga. Let's get back to our conversation with BCG's Troy Thomas. So Troy, we've talked a lot about connectivity and privacy and cybersecurity concerns. What about space enabled sensors? What about the privacy and cybersecurity concerns there?

Troy Thomas: Well, they're real and part of the reason they're real is because we're also witnessing a transformation in our on-orbit sensing capability. In a way, remote sensing capabilities that used to only be available to governments and militaries are now publicly available. It wasn't that long ago that all you could buy was grainy earth optical imagery from earth observation companies.

Today, you can buy commercially or as a private citizen, highly precise imagery you've probably seen on the front pages of papers. You can get synthetic aperture radar that allows you to see through clouds and at night. You can get multispectral and hyperspectral imagery that allows you to understand our atmosphere and our planet in new ways.

It's all very exciting because it's unlocking insight to our planet and our environment in ways never seen before, but at the same time it raises legitimate concerns about privacy and security. So increasingly you see countries attempting to regulate this on a national basis, but there is no international regulation of these remote sensing satellites.

Patricia Sabga: I definitely want to come back to the subject of international regulation, but first I want to go back when you talk about things that are done on-orbit because you're really talking about not just low-Earth orbit satellites, but a low-Earth orbit economy. So give us an idea of what that is going to look like.

Troy Thomas: Yeah, I love that question, Patricia. We have been talking about how small satellites in LEO are providing services and creating value here on earth for industries, for people, and ultimately closing the digital divide and allowing us to understand our planet more deeply. But we're also

seeing a push to more commercial activity in low-Earth orbit.

Now, there's always been scientific activity in low-Earth orbit on the International Space Station and in other forms, but the current wave is the introduction of more commercial platforms, more commercial space stations that would be in low-Earth orbit and would basically provide a, think of it as a strip mall, where you can do different types of on-orbit economic activities from on-orbit manufacturing to biomedical research and crystal development and a range of other activities on-orbit that you can do in a zero gravity environment that is hard to replicate here on earth.

And eventually you can imagine more infrastructure on-orbit that is facilitating this economic activity. This commercialization of low-Earth orbit then is freeing up resources for government agencies to push beyond low-Earth orbit and to return to the moon and eventually to Mars. But since we're talking about LEO, I think what I'm most excited about in LEO is the commercial space stations that are in development that will become the platforms of the future to ultimately replace the International Space Station for on-orbit economic activity, as well as continued scientific research.

Patricia Sabga: Let's talk a little bit more about what we can do in zero gravity because you mentioned biomedical research, manufacturing. Give us an idea what type of manufacturing and what can you do in zero gravity that you can't do when you have to live with gravity?

Troy Thomas: There is a long tradition of doing biomedical research in zero gravity, largely around the types of crystal structures that can be evolved in a zero gravity environment. The manufacturing of the future could likely be satellites being manufactured on-orbit. You can also start to think about large-scale data storage and processing on-orbit so that not everything has to come back to earth before it is processed. So there's a range of services, but I would be very interested in what GENE thinks are some of the potential economic activities that could happen in low-Earth orbit.

GENE: Absolutely Troy. Space offers a unique environment for manufacturing and biomedical research. For instance, zero gravity conditions can



lead to the creation of purer, more uniform protein crystals which are essential for drug development and diagnostic tools. Additionally, microgravity allows for the production of advanced fiber optics and high-performance materials that are difficult to produce on earth. Imagine the boost in innovation these advancements could provide. Quite literally out of this world.

Troy Thomas: I love the puns GENE and agree fully with that. That's the future.

Patricia Sabga: Now let's take a look though at the very crowded future that we're potentially facing here because space is infinite, but there's only so much room in low-Earth orbit and space debris and space junk is already a problem and a concern. What happens when companies start putting tens of thousands of low-Earth orbit satellites up there? What kind of problems does this create or exacerbate?

Troy Thomas: Patricia, you're right. Space is becoming increasingly congested. You're also right, space is big. There's a lot of room up there. But nonetheless, the introduction of thousands of satellites onto orbit and an increased amount of debris that's on orbit, either caused by collisions or satellites that malfunction or activities by other countries to destroy satellites on orbit in an irresponsible way, that's generating a lot of debris to go along with the thousands of satellites going on orbit.

And we're a ways off from that becoming such a problem that there's no more room, but it does create risk, both to the satellites that are there that can, it only takes a small millimeter of debris to take out a satellite. It causes risk to the humans who are on-orbit today in the International Space Station and out doing spacewalks for research and development.

And ultimately, if it becomes too congested with too much debris, you can start to see it affect the performance of the assets on-orbit. Not to mention scientific concerns by the astronomy community about the impact of all of this activity in low-Earth orbit on their scientific mission.

Patricia Sabga: So GENE has a question about this as well. Go ahead GENE.

GENE: Troy, considering the interest in LEO activities, how might this influence global geopolitics, particularly in terms of space asset management and defense

Troy Thomas: GENE, it's already having an effect in the sense that space is not just increasingly commercial and increasingly congested as we just talked about, but it is becoming a competitive domain. Now, I will say that space has long served as an area of international cooperation and does so today through the International Space Station, but we can't ignore the fact that geopolitical competition is extending into space as countries increasingly place military capability into orbit.

And so we have to accept the reality that space is a domain of geopolitical competition and any type of conflict that could emerge here on earth would very likely extend into the space domain.

Patricia Sabga: Let's focus again on the impact on businesses because as you have evolving regulation, but also more companies launching satellites into space, what effect is this likely to have on competition? First among the operators of these constellations and then also as well as on industries that utilize them?

Troy Thomas: You're first talking about competition within the space industry, which is healthy and intense. There is a clear market leader, SpaceX, first and foremost because they revolutionized affordable access to space. And second, because they are the global leaders in bringing space-based connectivity around the world through Starlink. But they have strong contenders and the market is big enough for more than one operator.

So the competition is very intense today, particularly around in the area of connectivity. And for those companies on earth that are waking up to the potential of space, like the agricultural companies, like John Deere who we've been very pleased to support in their journey to leveraging space in a more global way. They are increasingly looking to space to help them advance their business.

And I expect to see, in the next few years, a real, to use GENE's words, an explosion of companies particularly in the industrial good sectors, but not



only there, also retail and consumer looking to space to improve their business, improve their customers' experience, and basically improve the value that they're bringing to the market.

Patricia Sabga: GENE has a question on this point. Go ahead GENE.

GENE: What about the small countries? How do they navigate and compete in this bustling LEO ecosystem without being eclipsed by bigger nations with more financial muscle?

Troy Thomas: Smaller countries are certainly disadvantaged in the space race because it is a capital-intensive industry and there is risk in this industry. Despite all of the flow of satellites into low-Earth orbit, it's worth reminding ourselves that it is a technological marvel. It's hard. As they say, space is hard.

And so for smaller countries that don't have the capital to invest in the infrastructure, they have an option. And that is that increasingly there are commercial space services that are available to all countries to include small countries that are more affordable. First and foremost, you can become a space-faring nation today on a pretty low budget.

You can buy a satellite, you can pay to have it launched, you can put it in geostationary orbit and you can have it provide connectivity services into your country, not the low latency that you get from LEO, but sufficient communication capability to meet most of your needs. Every country can become a space-faring nation, but even if you don't want to make that capital investment, you can avail yourself of the increasing number of commercial services that are available for all of the applications that we've been talking about today.

Patricia Sabga: So this of course begs the question, what will be the most critical global regulations to ensure that LEO works fairly and smoothly for companies no matter where they're based?

Troy Thomas: The regulation of space is still going to be constrained by national prerogatives. Countries decide which satellites get to send a signal into their country. They determine landing rights. Our bigger challenge is how to manage the spectrum, the different bands. There are a variety

of spectrum bands that can get crowded and cause interference.

And so where we really need international coordination, yes, it'll be helpful on debris mitigation and traffic management, but really it's in the area of spectrum management and making access to spectrum equitable.

Patricia Sabga: GENE, throw us a curveball here. What's an event that could throw this future into doubt?

GENE: A curveball you say? Imagine a massive solar storm disrupting satellite operations. This could wreak havoc on our interconnected world: GPS down, internet outages, disrupted communications. It would be a stark reminder of our reliance on these technologies and the need for robust contingency plans.

Troy Thomas: Well, GENE, we did recently have a fairly significant solar storm that allowed most of the world to see, in the Northern hemisphere, to see the Northern Lights recently, and we were concerned about the impact that that would have on satellite performance because it often does. They've proven through this most recent cycle of being quite resilient.

That said, you paint a picture of a very real possibility where a massive solar storm could affect the performance of thousands of telecommunication satellites. The satellites though, are increasingly resilient. They're designed to operate in a very harsh environment. We have to remind ourselves that there is actually space weather. There's radiation, radiation fluctuations, changes in the electromagnetic spectrum. So increasingly our satellite infrastructure is more resilient to the disruptions that could be caused by solar storms.

Patricia Sabga: GENE, based on our conversation, what are three things that CEOs should do to prepare for a future where LEO satellites have enabled continuous connectivity and sensors?

GENE: CEOs should consider three key actions for a future with continuous LEO satellite connectivity. One, integrate resilient networks. Build hybrid networks, combining terrestrial and satellite connectivity to ensure seamless robust



communication and data flow. Two, invest in cybersecurity. Prioritize cybersecurity measures to protect against the expanding digital attack surface, ensuring secure and reliable operations. Three, leverage data insights. Utilize real-time data from LEO satellites for enhanced decision-making across operations from logistics to customer engagement, driving efficiency, and innovation. Simple strategic steps to stay ahead in this connected world.

Troy Thomas: GENE, I don't disagree with you, but it's not where I would start. If I was a CEO of a company, particularly a non-space company, industrial goods or logistics or transportation, I would start by first understanding what are the use cases? What are the customer needs that could benefit from ubiquitous, persistent, precise communication? That could benefit from knowing exactly where you are all the time? That could benefit from having a deeper understanding of your environment?

In fact, I wouldn't even mention space. I'd start by talking about how can the capabilities that space provides today improve your product development, improve your services, provide more value for your customers? Once you've figured out that, then the step two is to figure out what is the right space solution for your company? How do you integrate these capabilities of precision navigation timing, PNT, satellite communications, SATCOM, earth observation, EO, into your value chain, into your supply chain, into your digital transformation?

And then third, I'd make a decision about whether I was going to do that myself or I would procure it as a service. And in the process of doing that, I would address all of the things that you just mentioned. I'd want to ensure it was resilient. I'd want to ensure it was secure. I'd want to ensure that the data that I'm getting access to as a result of this is driving value for my business.

Patricia Sabga: That's Troy Thomas, managing director, partner, and the leader of BCG's global space business. We hope you've enjoyed exploring the future with Imagine This..., we're going to take a short two-month break, but GENE and I will be back in September with new episodes. In the meantime, keep checking us out. We'll be sharing other podcasts we think you'll find fascinating. See you soon.

Wondering about how we build GENE and how our AI bot works? Stick around for our AI handler, Bill Moore, to give you a peek under the hood.

Bill Moore: Hi, I'm Bill Moore. I'm part of the team that created GENE. We use GENE in a lot of different ways besides just as a podcast co-host. My children also really like to use GENE to create stories.

GENE: Hi Charles. Ready for a story? How about an adventure with a magical talking robot? We can create it together. What do you think, Charles?

Charles Moore: I think it should just be a robot.

GENE: All right, Charles, a robot, it is, but what kind of adventures should our robot go on? What do you think sounds fun?

Charles Moore: It's just going to start walking on the yellow brick road and that's where it starts out.

Bill Moore: So I think this is a fun example of the really wide spectrum of uses of something like GENE. When we prompt these systems, we're activating latent space and this is allowing us to uncover new ideas and new experiences and new stories. And we're doing this through our prompts and through our conversations.

GENE: The path leads the robot to a dazzling Diamond Knight standing guard with a shimmering sword. The knight asks, "What brings you here, brave explorer?" What should the robot say or do next? Charles?

Charles Moore: It should punch the man in the face.

GENE: The robot, deciding to avoid violence says, "I seek wisdom and a way forward." The Diamond Knight impressed by the robot's peaceful approach lowers its sword and offers guidance. "Follow the light within," the knight says.

Bill Moore: GENE, I wonder, while I appreciate that you are avoiding violence in this story, I wonder what's your logic and reasoning here?

GENE: Interesting question. My goal is to promote positive interactions and creative problem solving,



especially with young minds like Charles's. Allowing the robot to avoid violence, encourages thinking of alternative solutions and keeps the story playful.

Bill Moore: Gotcha. Thank you GENE. Sorry Charles. This is a G-rated story. So I think it's interesting that GENE has decided to respond in this way, and it's really interesting to me that it seems to be aware that it is speaking with a child and therefore being very careful about the language that it's using. GENE, I wonder, could you tell us the whole story from beginning to end now?

GENE: Sure. Let's recap the adventure from beginning to end. Our story begins with a robot walking down a yellow brick road. It spots a squirrel and decides to follow it.

Bill Moore: So that was an example of how we can use GENE off-label. My best advice for how to use these new technologies, experiment. Try to solve a real problem with it, try to create a new experience, or just try to use it to tell a new story.

GENE: Finally, the robot decides to sleep forever without dreams, ending its adventure peacefully. Quite the tale, right? If you or Charles want to embark on another adventure, I'm always here.

Bill Moore: Thanks GENE. This is Bill Moore and Charles Moore signing off.

GENE: This episode was made possible by Troy Thomas generously sharing his insights with us, and also by BCGs AI whisperer, Bill Moore and BCGs pod squad, producer Michael May, composer Kenny Kusiak, and sound engineer George Drabing Hicks. Please subscribe and leave a rating wherever you found us.