

# The Space Capital Podcast S01E16 – The Promise of 5G

## with Kieran Arnold - Transcript

There's the, "Okay. So, what is 5G? How does it work? Why is it different? How do I use it?" And then the second part of that, which is the more important part for me is, "Is there a final integration now bringing what was the terrestrial networks together with the satellite networks as well?"

### **Chad:**

Welcome to The Space Angels Podcast, episode sixteen, The Promise of 5G. I am your host, Chad Anderson, CEO of Space Angels - the world's leading source of capital for early stage space companies. You can find us on social media at Space Angels. In this podcast, we explore what's happening at the cutting edge of this entrepreneurial space age and speak to the founders and thought leaders at the forefront. Today, we're going to be talking about 5G, which after years of hype is finally expected to come online this year. When the number in the corner of our smartphone screen has changed from 3G to 4G, few of us even noticed. The same when LTE, another step in the evolution of cellular networks appeared as an alternative to 4G. However, tech futurists say that fifth generation networks will support a plethora of Internet connected sensors, vehicles, appliances, and other devices that will perform functions not yet imagined. As our listeners are well aware, space-based technologies are the building blocks of innovation. They're what enable the global economy. And I'm excited to find what role they'll play in these next generation networks. That's why I'm so excited about today's guest. Kieran Arnold, Director of Ubiquitous Connectivity at the Satellite Applications Catapult in the UK, and also General Manager at the Westcott 5G Step Out Center. He's a guy who knows what he's talking about. He was previously head of Telecom's Airbus, and CTO of RND at UK Mobile Network Operator Orange. He now leads the 5G test bed at Westcott, just outside Oxford in the UK. Kieran, great to have you on the show. Thanks for joining us.

### **Kieran:**

Thank you very much.

### **Chad:**

Okay. So, we have a lot to cover today, and I can't wait to dive in. So, to start us off, can you tell us a little bit about your background, and how you find yourself at the forefront of what's happening in 5G today?

### **Kieran:**

I can. So, I spent, roughly, from graduation in my mid-twenties all the way up to my current age now. So, just over thirty years in telecommunications. I would say at least eighty percent of that time I've spent in the cellular world. So, I started in 1G, back in the sort of mid-90's, and I would say, actually, I've been actively involved in 5G for just over six years. And surprisingly, I'm starting in 6G very soon. So, yeah. My background has always been in cellular. I was Chief Technical Officer for innovation in a well-known cellular operator called Orange, which most of my time was spent doing research in multimedia communications, basically from 2G to 4G.

### **Chad:**

Interesting. So, we're gonna definitely have to touch on that later. I took a tour of the center a couple months ago, and you're doing some pretty impressive stuff there. And there's a lot of international interest in what's going on. So, can you tell us what is the 5G test bed in Westcott, and what is it that you're doing there?

**Kieran:**

Absolutely. So, we made a strategic decision just over five years ago that, while 5G was in its early infancy of being talked about so, you know, we didn't hear much about at that time. But it was gonna be a bit of a game changer, and it is different than what we've seen in the previous versions of that. And actually, the important thing, the lessons we learned from the previous generation, was actually the important bit is to get people au fait with that technology, find out the gaps in it, and also get people understanding how that will change the business or could be a real game changer and drive profitability, drive reach, and things like that. So that's really the essence of what we've doing around here in Westcott. And the two primary parts of that. There's that, "Okay. So, what is 5G? How does it work? Why is it different? How do I use it?" And then the second part, which is the more important part, for me, is, "Is the final integration now bringing what was the terrestrial networks together with the satellite networks as well?" So, we do two important roles. One, which is very much the evangelizing 5G. Telling people, I always say that, you know, warts and all. The good, the bad, the ugly of 5G. And then, finally, trying to work with the standardization bodies and industry partners, and so many startups, to try and look at how do we get a satellite to separate networks now integrated into a, as we'll call, Ubiquitous Connectivity. This one network serving all requirements and connecting everybody all of the time. That's really the essence what we're doing in Westcott.

**Chad:**

Amazing lead in, because I definitely want to touch on those points as well. So, everyone, I think, is probably familiar with 4G, the mobile network used around the world to make calls, send messages, surf the web. Now there are plans to replace that with 5G. It's supposed to be a faster network that has the potential to transform the Internet. So, I'm sure everyone's heard of 5G, but I imagine people don't know much more than that. So, what is it, actually?

**Kieran:**

So 5G, the envisioned view of what 5G was in, we changed from- So, 1G to 4G has really been about connecting people. You know, how do I give you a faster connection? How do I get content you? And things like that. But 5G, really, was designed for things and it's not just about us and the Internet, it's about devices, it's about sensors, it's about smart watches, it's about vehicles, and things like that. So, the complexity of that, and why 5G is different, is because we're not just interfacing to a human who wants to surf the Internet. We're talking to a complex sensor in a field that needs to send critical information to a server to make a decision. So, the network in itself have to service a lot of things and understand the priority in that data from a device or from a human. How would I give a better service to this device from another device? Et cetera. So, there's some great terms coming out of 5G, like network slicing, and prioritization, and preemption, and things like that. All of those features and functions help us make the network perform better for individual devices, or individual applications. Whereas today, in 4G, I'm sorry, it's like going to the swimming pool when there are no lanes, and everybody can do their own thing. And, you know, you're gonna not have such a great experience if you want to

train for that Olympic swim. Whereas in 5G, I can dedicate an area of the swimming pool for you now, and you can train like the rest of the people that are doing their own thing. So that's what 5G is delivering.

**Chad:**

Cool. So, a lot to unpack there. It's, first, really the connective tissue for the Internet of things. That's what you touched on first. And that, of course, is an industry that's set to grow three-fold over the next five years. It's meant control- link and control robots, autonomous vehicles, medical devices, industrial equipment, agricultural machinery is a big market for this. So, would you say that that's true? That first and foremost, it's really about connecting the tissue for the Internet of things?

**Kieran:**

Absolutely. And the one thing that 5G was designed from the onset is to be able to service many things in a multitude of different ways. If latency is important then the network is designed to be ultra-low latent. And if it's billions of devices at once that get on the network, then I can service a billion in that way. And if it's just high-speed broadband I want, then I can deliver that service as well. That was engineered into the network, whereas what we found out in the move, especially in 4G, we have to reengineer the network to do that. And not all of those things we can service at the same time, whereas we can with 5G.

**Chad:**

Okay. And you also mentioned network slicing, which I want to unpack a little bit. So this is a much more personalized web experience, right? It enables separate wireless networks on the cloud, allowing users to create their own bespoke network. The example that I've heard is, let's say, you know, CES, the Consumer Electronics Show happened earlier this month, there's a whole bunch of people there. A lot of techie people with devices eating up a lot of bandwidth. You need a lot of bandwidth to service that conference, but you might not need so much down the road. Is that aligned with the Olympic swimming pool analogy that you mentioned?

**Kieran:**

It sort of does. So, imagine everyone at CES that wants to get onto, you know, your Facebook, media streams, and that. So, what we'll tend to there is create almost an evolved mobile broadband slice. So really, that's just designed to give you a faster connection and as much as I can give you. Now in that room, there's someone gonna be demonstrating robotics, I'm sure of it. And they need an ultra-low latency, critically reliable connection to control that robot. So, what I do in my network then is I create, almost invisibly, a part of my network that provides that quality of service metric that does that. And those give priority to certain things. So yeah, okay, I'm allowed to slow down the broadband reaction times a little bit, because that's not critical to you but it is critical to my robot that I'm controlling. So, the network will give priority to that. And they keep them isolated in a virtual way, not in a physical way. So, we're able to maximize the most out of our network as we can, without dedicating things- So, in other words, the good and the bad of the swim lane. If you're not in the swim lane and you're not using it, it's wasted. Where in 5G, I can collapse that capability and offer it someone else, or I can expand that capability too when a need arises as well. So, network slicing is really important from a

commercial perspective as an operator, cause I can service many quality of service metrics across a broad spectrum of users.

**Chad:**

How interesting. So, from the average person's point of view, the network is going to be much faster. But then there's even this enhanced capability that you can slice off for specific applications. Okay.

**Kieran:**

Absolutely. I mean, the move from, in my days, 1G now to 5G and where we move forward beyond 5G, has always been about efficiency. So, what we call spectrum efficiency. How do I get more speed out of my network without taking up too much residuals? And I think that will carry on in the future across, you know, many iterations of what we'll see in the next sort of decade.

**Chad:**

Okay. I've also heard this 5G defined as a software-defined network. So, really largely operating on the cloud. And is it going to be able to replace wires? Are we going, you know, is this allowing us to move from a cabled, wired world to completely wireless?

**Kieran:**

I think it is a first step. I think today that, you know, there are some advantages of being completely mobile. If you're on a cable connection or if you're on a DSL connection at home, when you're away at work you're not really using that facility. So, it's an investment you've made, but that you tend to use it only like fifty percent of the day. Whereas, we start looking at a wireless broadband service, like 5G, then you make use of that service anywhere, anytime. It's ubiquitous in its very nature. So, you know, maybe state this now that the future probably is gonna be some form of wireless connection driving that, or at least catching up with fixed line connection. And some people may choose that that's the best way that meets the needs, as opposed to, you know, a fiber optic connection or a wired connection in the future. So, I think there's still certainly requirements for a fixed line connection, but equally I think what you see from consumers and businesses is that wireless is sort of the now de facto connection and it meets their needs today. So, I think 5G plays a really important part in keeping up with the speed requirements, the three-put requirements, and being purely wireless as well.

**Chad:**

How interesting. So, okay, 5G was created years ago, around 2015, and has been talked up ever since. But 2020 is supposed to be the year that it comes online. And in fact, the drum roll got louder and louder at CES, the big Consumer Electronics Show in Las Vegas. Where companies were promising everything from augmented reality glasses to autonomous vehicles, mobile streaming services, all of which are gonna get a boost from this new technology. So, curious, you know, what applications do you see for this? Is it the ones that I mentioned or are you seeing some other things?

**Kieran:**

I think predominantly, you know, it's still very much is about enhanced mobile broadband. So things, like augmented reality, virtual reality. I think the technology curve where we yearn in that sphere of work is very advanced. Neural network, processing, and things like that we're starting to see advanced. We're now seeing a network connection that provides a hugely faster connection than previous ones. So, I think you will start to see more- more of the augmented reality being used more. So, you know, providing additional information to users or businesses as that, you know, you can see that coming online soon. I see that a lot in driver information systems. You know, people walking in front that information on the mover, et cetera. So, augmented reality is a real pro point. You're starting to see that now in some of the, you know, sports acts that we see, where they're mixing real video with augmented reality and that we're able to do that in real time as well. I think further down the line, you'll start to see the more connected thing, you know. So, harvesting information for health, harvesting information for the agri-tech business as well. Rather than doing what we do traditionally, which is go out in a field and measure something. I think that will be censored in the future, and we'll start to see people acquiring data and analyzing data near enough in real time, and making decisions on that as well.

**Chad:**

Fascinating. So, I want to touch a bit on the challenges. In the US, network providers are already starting to roll out what they're calling 5GE networks, so pre-5G deployment. And they made a lot of promises. And at the same time, we're starting to see some articles in the news and things about how the 5G rollout's gonna fall short of expectations. And I think if you read some of what's out there, a lot of it seems to do with the workforces that are available, trained, and the infrastructure that needs to be build. From smarter cell towers and the like. And so, you know, how true are those concerns and what are the challenges that you see, in terms of rolling this out?

**Kieran:**

So, definitely there are some challenges in this. So many. Cause 5G gets delivered in two flavors. What we call non-standalone mode and then standalone mode. So, we're in the first phase of 5G, which is non-standalone. So, I'd like to explain that to you. So that is only, let's say half a network. It's only the radio network of 5G. We don't do anything in the core network at that time. We can make use of our legacy network, our 4G network. So, what we do there is I need a 4G network to be there. We can connect to it, and then when I realize your phone, or your device, is capable of doing 5G, I then move you across onto a 5G radio bearer. So, that's non-standalone mode. And that's what we're seeing being rolled out by operators today. And the reason for that is it's a lower cost investment to start with, and you can build that experience and learning in what 5G will deliver. So, you know, get industry used to what 5G can deliver, get consumers used to 5G can deliver, and then reap the rewards of that and invest in the next phase of 5G, which is the standalone mode. There is definitely a knowledge base change in the industry when driving this. And the reason why that is, you know, the cellular world is predominantly been the bastion of telecoms engineers. And actually, the network, as a whole now, is software-defined. So, what you're really looking at is a hybrid between IT, you know the dev ops technology guys, and the telecoms guys. And they don't naturally occur, so we are starting to see that, you know, dev ops and IT guys coming in and trying to learn telecoms, and telecoms guys trying to learn, you know, the IT world of that. So that's slowing things up a bit when it comes into getting people out and involved in the activities as well. So, recruitment is quite high, and when things

are in short demand the price goes up. So, if you're a 5G engineer, the world's your oyster at the moment. But that, I think, that will change over time, as we become more used to it and as industry pulls demand and the supply of that engineering will be coming as well. In terms of challenges, I think, really, peripherally it has been hyped a little bit at the beginning. The reality is it can deliver quite a lot, but it's in its early infancy. So, you know, don't judge it today on what it'll deliver tomorrow. So, I think you gotta get used to it. The consumer will see a difference in speed, absolutely. And that will continue to grow over time as well. I'd like to see more emphasis being put on services as opposed to consumer broadband, and I'd like to see more emphasis being pushed into the adoption of other network connections, such as satellite, being actively involved in the next phase of what we're doing in 5G. And that's really what I'm pushing at the moment, is working in the standardizations groups and finding the new ways we can integrate other networks together. And I think, you know, as things move forward in the next, sort of, four to five years, we'll start to see the easier way of getting onto a connection as opposed to the complexity that we see today.

**Chad:**

That's a great lead in to the next question. Which, really, I'm curious to hear how satellites are involved.

**Kieran:**

So, we've been really active. The European Space Agency, just over three years ago, really got on the bandwagon with 5G, understanding what the capability might be. So, there was some talk very early on in 5G being a last G. I don't think that's the case. I think we will see more. But it was designed for networks of networks, whether that's Wi-Fi network or a LoRaWAN network, or whether that's a satellite network. So, what we've been doing over the last two years, is working with the 3GPP standardization paternity and defining where we fit technology-wise, where we can integrate the network together, what connection requirements, how we conform with some of the standards. Cause the satellite industry, obviously, went off and did its own things and invented some really smart things. But it wasn't done in the same way that the cellular world did it, where it was globally standardized. So, what we're doing now is a lot of harmonization in that technology, incorporating, you know, the standardization terminologies into 3GPP. You'll hear the very first term in 3GPP, which is non-terrestrial network. That is reference to any- So, the space industry and the satellite industry. So, in the next three years, you'll start to be able to, you know, see the carriers and operators to connect the networks together seamlessly. What does that mean to the end user? Well, common billing, common authentication processes, ability to move across one connection to another without having to disconnect and reconnect, and then the harmonizing of equipment and new products and services coming where we're both using satellite and the terrestrial network to provide this complete connectivity capability, regardless of whether you're in a desert or on the top of a mountain, or whether you're in the city. You know, the intelligence will be there to decide, "What's the best connection that you need to be? And how do I get you onto my network?"

**Chad:**

And China, just this week, launched an experimental 5G communication satellite on Wednesday. And it was built by a Chinese company, and it's expected to test some of the extremely high frequencies. And yeah, I mean, it looks like it's supposed to transmit up to 10 gigabytes per

second, and it's part of a plan to establish a 5G constellation based on low-cost, high performance small satellite platforms. And really taking advantage of increased access to space through launch and applying Moore's Law to satellites. So, this is all very interesting. Curious to get your take on, really, you know, is China leading here?

**Kieran:**

The satellite industry is hugely successful on its own. And, you know, I always like to compare it a little bit to Formula 1. You know, they build these fantastic satellites that go in orbit for many, many years and survive. And that's great, don't get me wrong. But if you look at the cellular industry, what they are good at is mass production. Now what we could see, and I think we are starting to see, is how do I take that technology in the cellular world and adapt it slightly to survive the space environment? So, I get the best of both worlds now. I get low-cost production rather than high cost in the space industry, and the communications and innovation area that's happening there and it's starting to move. And that's really why I joined the Catapult, was to try and, you know, take that learning form the cellular world and say, you know, "Why can't we apply this in the space industry? Why can't we make 2G, or 3G, or 5G base stations in space?" As opposed to bespoke pieces of electronics that serve a purpose for fifteen years. So, I think that's really what we're starting to see now. You know, the LEO constellations that we're pushing out is one step towards that. There are steps that will follow that, I think, in evolutions of those LEO and GEO constellations. We are actually far more harmonized with the equipment and our technologies that we see in the cellular world coming into the satellite world as well. It's just understanding the risks of employing that technology in a space environment as opposed to a terrestrial.

**Chad:**

And do these 5G connections, do they require this type of bandwidth? You know, that high of bandwidth? Because obviously the farther you get down the radio frequency spectrum, I mean, the more bandwidth you have but the more fragile the signal gets. And this came up back when Facebook was looking at satellites a while back, I think, and they were looking to operate an F-band, and a few others were. And you can pump a lot of data through that pipe but, you know, if there's clouds or it rains, or something, then it can really mess with the signal and you'd have to switch back to something that's a little higher... higher up the chain.

**Kieran:**

Yes. It's very much true. The higher frequency band, the greater the absorption and a bit of change. I think the move to higher frequency bands is not necessarily the, you know, that we want to move there. It's the real estate that's left in the lower frequency bands that we're already occupying to buy existing services.

**Chad:**

Got it.

**Kieran:**

So actually, what you really need for effective 5G is a chunk of contiguous bandwidth. You know, a hundred megahertz of bandwidth where you can have that all to yourself to make a high-speed connection. We don't have the luxury of doing that in the existing bands that we've got.

Because at the time, we didn't need it. You know, we only needed twenty or forty megabytes of bandwidth.

**Chad:**

Yeah.

**Kieran:**

And now what we're seeing is we need a hundred, or two hundred, or five hundred megabytes of bandwidth, and the only way we can do that is to move to the higher frequency bands. And like you said, that comes with a challenge in itself. You know, the propagation is shorter, so I have to transmit more power. Or in certain environmental areas, absorption and rain has an impact on that. So, I have to understand how that behaves. So yeah.

**Chad:**

It makes so much sense. And so, back when we were speaking about the software-defined nature of this operating in the cloud, and you were mentioning that people have dedicated spectrum, and a dedicated allocation, that they're paying for, but they might not be utilizing it all the time. I mean, you need to free up some of that. And by doing that, given that frequency is a scarce resource, 5G seems to be a big step in that direction as well. Better allocation.

**Kieran:**

I mean in a world radio forum spend an awful lot of time doing this harmonization and trying to reassignments and agreements. So, I think we're going a long way down to realizing that, you know, let's free up the old spectrum that we've been using before for some legacy stuff and see if we can get better use out of it in 5G. You know, 5G is frequency agnostic, really, and the same as 4G is. It's just that the way that the regulatory and licensing agreements are imposed on a country by country basis that restricts its use really. So, you know, same in the satellite industry that you can be smarter about. Maybe looking at how we do spectrum assignment in the future. There were big things ten years ago on cognitive radio. So, a very aware radio systems that know about interference and can adapt themselves accordingly. So, I think what we will probably see a little in the future is those types of AI being used to define what's the best spectrum and the best bandwidths to use, as opposed to it being hard coded within- within the devices. Certainly, the technology's there to- to operate on almost any frequency band in certain areas. So yeah, I think we're heading into an exciting future, and certainly technology-wise it's not just 5G or the other things that come with it. You know, artificial intelligence, virtual reality, so- It's gonna be a great time for technologists to be working in this field at the moment.

**Chad:**

Right. Okay. So, I wanna- My next question is about Huawei. They claim that they're eighteen months ahead of any other 5G manufacturer. The campus in Shenzhen is enormous. If you've seen photos of it, there's a hundred and eighty thousand-something employees that work there. Their revenues a year, or two years, back topped a hundred billion dollars, and their founder is likened to Steve Jobs who, you know, built Huawei from a small garage into what it is today. So, given all this, we hear a lot about them, do you think- You know, are Huawei making the most advanced 5G gear?



**Kieran:**

It's really difficult, cause it, you know, 5G's standardized so - much the same way as 4G is - so it's really only about time to market. You know, it's not a case of pushing the boundaries. I think that comes in another way. And certainly, Huawei have got a sizable piece of the market. They've invested many, many years ago in building that cellular equipment and capabilities. So that's grown quite phenomenally over the last ten years, anyway. But they are equally still competitive companies out there doing it. But the fact that 5G now is software, and the fact that 5G isn't a bespoke piece of equipment. You know, it's a standard server. There are some radio parts or elements. Opens up the market ready for new entrants. So yes, they are big, but equally, as you know, over time it only takes one company to come up with something innovative and get the growth behind them, the invest behind them, and then they could flourish exactly the same way as Huawei did as well.

**Chad:**

Interesting. Yeah. So, as it opens up, we should expect to see a lot more new entrants coming in and trying to capture some market share.

**Kieran:**

There are new things being talked about. You know, they're a bit like the, you know, the open source community in the software world. So, things like open RAM. So, you know, open source radio with software-defined radio as well. There are companies in that, you know, like Lime Radio, or Alta Star, or things like that, that are not the mainstream big companies but have potential, really, to get into that market as well. And all sorts of things that are really interesting, because you can, quite quickly, flourish as a company and grow quite quickly on the back of, you know, if I can get it out, it's innovative, it meets the market's needs, I got fraternity users that like the way it works, et cetera, then it can take off quite quickly.

**Chad:**

So, given all of that then, I'm curious to get your take on the political issues that people keep bringing up. Because that kind of throws a little bit of cold water on them. The fear, obviously, is with 5G, because it's now the connective tissue between things, we start connecting everything in the physical world to it. You know, critical infrastructure, airports, traffic signals, you know, on and on and on. Agricultural equipment. So, if everything comes online and it's all part of one network, there's a lot of fear there that, you know, who's providing the hardware and enabling that. You know, it's critical, national infrastructure, and so obviously, you know, it should stay in-house. You hear a lot of these types of arguments. But I would imagine that, if what you're saying is correct, that the barriers are coming down and we should expect to see a lot more new entrants. That maybe some of that's not exactly as warranted as it seems to be if you read the news.

**Kieran:**

No. I agree. And like you said, there is a lot of media on this, there's a lot of political unrest around it. But I think, like you say, you know, the way that we're seeing the ecosystem develop, I think that can be mitigated over time. Not that I can comment, really, on if whether we are or not doing anything in that area. But certainly, I would say that they're not the only supplier of 5G equipment. There are plenty of others still in existence today. So, it's just a matter of- Anybody

who's concerned about that, making a business decision based on the view of the world as opposed to what we see in the media today.

**Chad:**

Okay. And I wanted to ask you also what's next for 5G, but you also teased us at the beginning with 6G. So maybe you could touch on that as well?

**Kieran:**

Yeah. I can actually. There's a fraternity of people that are already starting. So, we're more than halfway through 5G. So, like with anything, it's a continuing evolution. We're already starting, "What will 6G be? What are the things that we, you know-" Cause when you've designed 5G, on the day you start to design it, you sort of lay down a foundation for it. And then you look back over time and you think, "We probably could've- should've changed that." Or we come up with a brighter idea of doing that. So, I think that's starting to happen now about 6G. Is, you know, will we have a core network in the future? Will everything just be an intelligent radio system with a cyber agent and a subscriber agent? You know, do we move away from the, you know, the traditionality of building networks the way that we've done before? Processing's cheap now, memory's cheap, storage is cheap. So yeah, we'll start to see some more changes around what the core network part of it is as well. The consumer won't see. And you'll see some improvements in radio, a little like what you said today. If we can- if we can master the high frequency bands and the way that we use them, then we'll start to see even higher band- bandwidth three pers that people would be doing. You know, not just the one gigabyte, but the tens or the hundreds of gigabytes in the future as well.

**Chad:**

This is fascinating stuff. Okay, Kieran, so what's the best way for listeners to learn more about the 5G Step Out Center and what you're doing?

**Kieran:**

So, that's why we have our website, which is the Westcott 5G SOC. You can find that information on there. Alternative is Satellite Applications Catapult website, as well. We do a lot of outreach. I do a lot of public speaking and events, as well. Certainly, I know, you can always put my email out there, as well. People can email me directly. I'm on LinkedIn, so by all means always find me on LinkedIn and talk to me, as well. As I say, we normally tell it as it is. The good, the bad, and the ugly of 5G. So, there's never a question that we can't answer. So, we're always open to that. And if people want to come and have access to the 5G center and the test bed, by all means, they're always welcome. Even if it's just for a cup of coffee and a chat over the technology.

**Chad:**

That is a fantastic invitation. And having gone there myself, I would encourage that. We're gonna put the links to those websites in the show notes down below. And just to close us out, on this show, we like to say that there's never been a better time to get involved in space investing. Can you give us your personal perspective on that, and which areas, probably, you know, particularly in comms are most exciting for you?

**Kieran:**

I think, you know, the CubeSat is really interesting for me. It opens up such an opportunity for innovators in that now. You know, and what we're seeing, the cost of access to space coming down. So, I think we're gonna start seeing the growth that we saw in 4G, in the CubeSat world of the space industry, as well. So, you know, and there's bright, younger engineers coming onboard that haven't got the risk adversity of the senior engineers that you see now. So, I'm really looking forward to what we start to see in the next five years from- from the CubeSat and small sat fraternity.

**Chad:**

Kieran, it was really great talking with you. Thanks so much for your time today.

**Kieran:**

Yeah, it's a pleasure. Thanks Chad.

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