Episode 212 – Holy Grail of Connectivity, Seamless Roaming and Multi-Band Antenna Technology

Speaker: Ryan Stevenson, Senior Vice President and Chief Scientist, Kymeta – 28 minutes

John Gilroy: Welcome to Constellations, the podcast from Kratos. My name is John Gilroy and I'll be your moderator. The promise of seamlessly roaming across satellite networks in different bands and different orbits is that much closer to reality. A new breakthrough in multi-band antenna technology holds the potential to make communications as seamless and automated as the cellular networks we use today. Here to discuss the innovation in antenna technology is Ryan Stevenson, Chief Scientist from Kymeta. He is going to talk about the capabilities of the new multi-band antenna technology and discuss the potential it offers to redefine SATCOM connectivity for a wide range of applications from military to aero. Wow, Ryan, we got a big promise with this open, don't we?

Ryan Stevenson: Yeah, we sure do.

John Gilroy: It's really amazing when you see the technology has changed just in the last five or six years. So I talked about a breakthrough in the open, so what does this breakthrough mean for the viability of a network of networks approach enabling seamless roaming across orbits and bands?

Ryan Stevenson: Yeah, this has been described as the holy grail, right? I'll reference the military use case, the Space Force produced the satcom Vision white paper about five years ago that talked about the need for what we call the Uber terminal that will work across bands, across orbits, across waveforms, and allow the military to have one terminal, satcom terminal that does it all. And the antenna has always been a fundamental issue there, and especially as you say, okay, well parabolics have existed, multi-band parabolics have existed. In some cases you have to change out those feeds to change bands. But as use cases have shifted more towards mobile applications, both military and commercial, parabolics are challenged in a lot of mobile use cases, especially land mobile use cases where a lot of the volume is being driven. So you really didn't have to rely on ESA, electronically scanned antenna.

And the ability to have a multi-band ESA has been a challenge for a long time. And so what we've been able to do with this breakthrough is combine KU and KA ESA functionality into one physical aperture, so one antenna that can cover these bands and interoperate simultaneously across KU satcom bands and KA satcom bands. And so what that allows, if you think about a future where people are talking now about AI network management, this is being talked about a lot in 6G, having simultaneous links on KU and KA and the ability to switch orbits, MEO, LEO, GEO, it really enables this sort of AI based network management approach and being able to dynamically allocate network resources depending on traffic, depending on whether you have an interference event or a weather fade event to dynamically balance and load the network appropriately from a single user terminal.

And this starts to look, you mentioned in the beginning, a lot the way cellular works today. I would say satcom today works a lot like 2G cellular, bespoke networks, terminals that are locked to a particular band and a particular network. And as much as the industry, the satcom industry, wants to pivot away from that, the antenna technology has to enable it too. So this is really what this breakthrough is about.

John Gilroy: So Ryan, I got up early this morning and typed in some different phrases, ESA for example, electronically steered antennas. And so what I've discovered, I mean, it already offers this multi-band connectivity, right? So what makes this new technology unique and better?

Ryan Stevenson: Yeah, so I think when you look at what's been done historically, and especially in aero use cases, and if you have a platform that's big enough and has enough power to deliver, you'll put four phased arrays on an aircraft frame and call it a day. For full duplex comms, you'll need a KU receiver array, a KU transmitter array, a KA receiver array, and a KA transmitter array. And you see these implementations now on more wide body aircraft under these sort of standardized mounting configurations. And these are like ARINC 791 and 792 standard installations.

But then the challenge really becomes, well, like I mentioned land mobile platforms earlier, but you don't have the room, you don't have the power delivery capability to do that, right? So when we think about how our technology even today is used on these incredibly small pushing this kind of capability to the tactical edge in the military use case, we install our products right now on things as small as what's called an M-razor, which is like a four-person dune buggy, right? And we can provide multi-orbit SATCOMs today on those kinds of platforms where they're very power constrained.

That's really where the difference comes in is that the way we've extended our metamaterials approach, still very low power consumption, and that means between a factor of five and 10 lower power consumption than traditional phased array approaches, being able to then deliver the multi-band connectivity as well as the multi-orbit switching to those same types of platforms. So it really enables tactical edge platforms. And now that the interest is switching towards things like unmanned surface vessels, UAVs, those are all still very power constrained platforms, small, highly mobile power constrained platforms where you can't afford to put a kilowatt phased array on that and have a solution that works.

John Gilroy: Ryan, if you get out your history books, you'll learn about the quest for the holy Grail. It was a challenge. I mean, it wasn't easy. People spent the whole lives and not find it. And so let's talk about challenges for our holy Grail today. So what technical challenges had to be overcome to reach this milestone?

Ryan Stevenson: Absolutely, absolutely. For us, as we've matured our metasurface technology, we've launched KU band products, the most recent instantiation of the antenna technology we launched in 2020. We've had a variety of derivatives since then. We've also demonstrated the approach in KA. We haven't productized the solution there yet, but we've matured our KA technology to a point where we saw a path to actually combine the two. And so then rather than launch a specific KA product, we said, "Hey, let's skip a step and really skate to where the puck is headed."

And so the challenge for us then was to figure out how to interleave, I mentioned you might have four phased arrays that cover these separate bands, so for us we have these separate subarrays that we interleave into one physical aperture. We do it right now in KU with transmit and receive, and we've done it in KA with transmit and receive. And now the trick was to figure out how to overall design the metasurface so that we could interleave these four subarrays into one physical aperture. And that required us to figure out how to define an array periodicity that would work both at the upper edge of KA as well as the lower edge of KU. And once we defined that, what we call a master unit cell, and then array that out, we had the capability then to go and build this.

John Gilroy: You mentioned multi-band, multi-orbit, I've been taking notes here, so I got to ask the what question here. So what enables this antenna to switch back and forth between LEO and GEO and multi-band, multi-orbit? It seems like a lot of flexibility there, doesn't it?

Ryan Stevenson: Yeah, absolutely. I mean, one of the really unique things with the way we do it is it's all really done in the software. Once we have the multiple bands integrated, that's obviously in the hardware, but controlling what orbit we're working on is all in the software flexibility of the antenna.

One of the things that's required, it's table stakes for multi-orbit comms, is that you have to have polarization agility. And so what that means is on a KU band LEO, whether it's OneWeb or Starlink, those are circularly polarized systems. And so a lot of the solutions that you see there, they use a fixed circular polarization and that polarization swaps right-hand or left-hand if you're doing transmitted or received, but it's a fixed polarization. And that's a specific design choice and systems implementation to reduce power consumption and reduce costs for phased arrays, because when you have to become pull agile, now in a phased array you have to double your channel count because each antenna element you have to feed with two channels. So now you double up on the phase shifters, you double up on the amplifiers.

And so when you look at multi-orbit phased arrays, now the power consumption goes through the roof, you're really talking about several hundred watts to be able to switch orbits between LEO and GEO. For us, in the metamaterials approach, it's really just a software change because we get that polarization agility simply through the way that we implement this metasurface and control, this gets a little bit more technical, but what we do is this diffractive implementation of a metasurface and how we control that. So in software I can, through how I control the excitation in the metasurface, switch from circular to linear polarization. That's what you need to do to go from KU LEO to KU GEO.

You also have to be able to be full duplex to talk to GEOs. Most of the LEO systems you can get away with being half duplex because you don't have that much speed of light delay, but to communicate all the way out to GEO, because the speed of light delay is so long, you really need to have full duplex communication. So those two things need to be implemented. And so when we've done the KU KA array, we have full duplex again in the same aperture on both the KU and the KA sides, and then we still have this software-based polarization agility, which is really what you need to be able to switch between LEO and GEO constellations.

And then the third thing that you need, sorry, one more point, but the third thing that you need is enough EIRP, enough radiated power to be able to go all the way out to GEO, and that's something that we also are able to do much more efficiently with the way that we feed the antenna.

John Gilroy: You talked about being technical, we have listeners this podcast all over the world, and for the technical people who are loving talking about polarization agility, bit there are other listeners that are more interested in the economic benefits of this technology. So let's take off your technical hat, Ryan, put on your business guy hat or whatever you wear there. So from an operator's perspective, what economic benefits does the consolidation of multi-band capability bring?

Ryan Stevenson: Yeah, absolutely. I think one is there's a huge logistics footprint. Thinking about a military customer, and I'm remembering a data point that I heard from a satellite show conference a few years ago, this was maybe like '21 or '22, there was a panel discussion and the fellow representing DoD was saying that they have to maintain something like 130 different types of satellite communications equipment to work across different constellations and different use cases. And so one of the arguments here is about for an operator reducing the logistics footprint of having to maintain a bunch of different SATCOM gear. So that's one thing is that it allows you to just eliminate hardware, right? Now you have one terminal that can operate across different constellations and different bands, you don't need to carry all this other equipment. So that's one argument.

But then it also brings about more software-defined capability. So in general, that allows you to streamline your operations. You can think about more software-defined networking capability and not needing such hardware-defined capability. And I mentioned Kymeta is a big supporter and a fan of organizations like Diffy that are trying to standardize and remove a lot of that hardware-based implementation and replace it with more software-based implementation, so this technology will facilitate that move.

John Gilroy: So Ryan, I pick up my phone and look at the news, it seems like every day, every other day there's another launch and the number of satellites going up there, it's just almost like it's another bus coming by, it's almost that common. So as more and more LEO constellations come online, how will this antenna architecture shape global roaming and network interoperability?

Ryan Stevenson: I really think that this technology facilitates what's happening in the SATCOM market in particular. But with more and more LEO constellations, there's a couple of different angles to look at this. So from a competitive perspective, when you say, okay, we've got Starlink and Kuiper, and as disruptive as they are, I still look at those constellations a little bit more like sort of the legacy proprietary networks, right? They're kind of doing their own thing. But then what you see happening in the traditional operators is this consolidation. So SCS and IntelSat just closed, Eutelsat OneWeb was another example of where you see this consolidation in an effort to compete. And that consolidation is invariably going to drive towards hybrid networks. I mean, with SCS and IntelSat now you have a situation where SCS empower MEO, which is in the KA band, but they have a lot of KUGEO capacity, IntelSat has a lot of KU GEO capacity, but also has purchased a lot of OneWeb capacity. So now you have this potential for this hybrid network that's going to need to bridge between KU LEO, KU GEO, KU MEO.

And so having one user terminal that could interoperate across that kind of a hybrid network really facilitates this kind of move in the industry that we see towards consolidation and hybridization. And so in the one sense there, to answer your question in a way about more LEO launches, if it's more Kuiper and Starlink LEO launches and what's happening then with the rest of the industry. But even the new constellations like Iris Squared, that is intended to be a multi-orbit, multi-band hybrid network. And so those kinds of constellations in my perspective don't even really become feasible without intended technologies like Kymeta's.

John Gilroy: We opened up talking about the holy Grail and I think of Ron Burgundy saying, "Hey, this is a big deal." And I guess it is a big deal. So let's take a couple of vertical markets here, for example, so why is this new technology, maybe this hybrid application, why is it so important to the military and commercial verticals such as aero?

Ryan Stevenson: I think from the military perspective, we'll start with that one, I mentioned the white paper that the Space Force wrote in early 2020, and so for them it's been a key desire for years and for many reasons, the military, its network resiliency is a huge deal, very high availability network connectivity with the ability to do what they call PACE planning, which means, you have, PACE being an acronym, primary alternate contingents and emergency communications paths. And so they have for a long time wanted the ability to say, "Okay, maybe my primary link is on this particular LEO in a particular band, but I have an alternate link I'd like to fall back to that maybe is this GEO on this other band," depending on where they are in the world and what they're trying to do, what their mission looks like.

And so this ability to interoperate across bands and orbits really fills that requirement for the military across a variety of platforms. I mentioned USVs, I mentioned really highly mobile tactical edge platforms where you're trying to push this level of connectivity as far into the tactical edge as you can. And so then having the solution but also have it be very low power, very compact, low size, weight and power is really key to enabling that vision for the military of getting this into the tactical edge.

On the commercial side with aero, I think there's an interesting thing developing there where you see a desire to start bringing different networks into the aircraft. And that could be something like providing high throughput, very low latency over a LEO, but maybe less latency sensitive traffic could be balanced and passed over a GEO even on a different operator or a carrier. And so this multi-band, multi-orbit capability gives commercial aero, in-flight connectivity operators, that kind of flexibility.

John Gilroy: You mentioned the variations of platform, let's kind of mix it up and talk about different areas here. So how do you see this innovation affecting business models for manufacturers, carriers, and end users from now the next five years?

Ryan Stevenson: Yeah, I really think that this technology is going to help make the push or help drive the push towards standardization. And take terrestrial sailors as a model from where they were in the 2G cellular days to where they are now, where everything's built around standards, and I don't have to worry about whether I have a CDMA phone or a GSM phone and is it going to work in Europe or that kind of thing. That's kind of like the conversation you have now in SATCOMs, right? And even with DVB-S2 and other standards, there's still flavors and there's still these proprietary networks, but having the antenna technology that says, "Hey, now this antenna can interoperate across these different networks," I think it's going to help drive further standardization towards standard waveforms, more and more standardization around the air interface in general.

And I think for manufacturers and carriers, that's going to be a very different business model than the one they're used to working in right now. Organizations like Dify are going to help drive that as well and allow for more software-based processing rather than these bespoke hardware solutions. And so you can imagine this type of agile antenna and then having software-based processing. So I think, "Okay, if I want to work on this particular waveform in software, I can make that happen," versus this other waveform versus having to have physical modems stuffed into the terminal to make that happen. So I think that's one big change that's going to happen over the next five years.

And for the end users, I think they're going to be able to just leverage the benefits of that kind of standardization, and so they're going to be able to think beyond these traditional stovepipes proprietary networks and what does it really mean for my business if I can just interoperate now across all these different networks and really plan for interoperability and a much higher degree of network connectivity than they've had in the past. I think overall for the end users then it's going to help them reduce costs in their business models over where they are today.

John Gilroy: So I think the headline of this discussion today is a breakthrough in software-defined antennas, so let's maybe amplify that a bit, okay? So do you also see modems becoming software-defined to enable an even more efficient network? Is that the next step?

Ryan Stevenson: I do, I do. I think that's going to have to happen, or at least as standards become adopted, then at least you can get to a point where I'll have a MediaTek or a Qualcomm 5G chip in my phone, you can get to a similar point with three comms or even 5G and TN standards that are being developed now by 3GPP, you maybe have a common chip set now that comprises both terrestrial and satellite based waveforms. And I think that's eventually a future state that we're going to get to. But I think software defined processing is an intermediate step there because you still have all these disparate SATCOM networks and waveforms and air interfaces that exist.

And I think a next step is, it's already happening at the gateways, and I think it's a next step to then get it into the user terminals. So having very compact, efficient, FPGA based processors that are going to be able to say, okay, if my antenna is switching networks and I'm going to go from this KU LEO to this KA MEO, and now I need to also switch waveforms, I'll have the FPGA based processing to be able to say, "Okay, now I have that IP and I can switch in the user terminal and start demodding or implementing a software-based modem to switch." There's a challenge in the industry right now, there's this reticence to say, "Okay, here's my IP block." That's a business model that has to shift as well in order to make that happen.

John Gilroy: Let's have a little bit deeper dive into this multi-band capability. If you look at it from like a consultant detached perspective, you look at it, you go, well, can this multi-band capability accelerate the adoption of edge AI or maybe even autonomous systems across, I don't know, defense, maritime and mobility?

Ryan Stevenson: I think it can, or I think it will. There's actually something that stuck with me, I saw a quote that came out of NVIDIA last year, and it is really kind of stuck with me because what NVIDIA was saying was the connectivity fabric becomes essential to AI. And when we think about edge AI in particular, and that becomes dependent upon ubiquitous computing. And ubiquitous computing really hinges on ubiquitous connectivity. And that's actually one of the ideas that's being sort of percolating around the 6G community is this idea of pervasive connectivity. If you're talking about inferencing on a phone or other edge AI powered interactions from device to device, latency, connectivity all become essential. And so I think extending that in the 6G sense to not just terrestrial cellular, but GEO, MEO, LEO, every networking modality needs to be brought to bear to manage all the traffic and balance the network. I think this hybrid capability of interoperating across KA, KU, GEO, MEO, LEO, it really becomes essential to providing that level of connectivity that's required to accelerate edge AI and other AI applications.

John Gilroy: Let's take a look at the technology from another perspective here. So how do you see this technology evolving into maybe a product in terms of timing and customer applications, do you see any of that in the future?

Ryan Stevenson: Yeah, so Kymeta, what our recent announcement was about was core technology demonstration, like, "We've developed the core technology to do this." And now really we're off to the races on product development. And so for us, our near-term roadmap looks like initial availability in '26 and product launch in '27. We're actually looking at a couple of different scenarios where you can have something that looks more like the DoD mil-spec product that we have in the market today, or something that's going to look more like a commercially-oriented product. And we're actually going through that definition right now. But we'll likely have two products, one that trails the first some amount of time later, but a DoD mil-spec type of a product and a commercial product are both in our plan right now.

John Gilroy: Ryan, people who've been listening have heard you mention KU and KA Heard you mentioned 5G, maybe even 6G. So let's put it all together, let's put everything on the room on the table and put it all together here. So let's look beyond the KA, KU dual-band, do you envision extending this approach to additional bands or integrating with cellular 5G, 6G technologies creating a truly universal terminal?

Ryan Stevenson: Yeah. Well, honestly speaking, that's been Kymeta's vision since 2020. When we launched our second gen product in 2020, we were the first to launch a multi-network product. We combined 4G cellular with the KU GEO SATCOM link in the same terminal, and we orchestrated that through an SD-WAN in the cloud. And that's actually been a capability of our product ever since. So when we launched, we call it the Osprey HGL, hybrid GEO LEO, hybrid means terrestrial cellular.

And so we launched that product in 2024 at Satellite show. So that now then combined the hybrid terrestrial cellular side 4G in this case, but with geostationary, KU GEO and KU LEO, not simultaneous, but able to switch across any of those networks. As long as you had terrestrial cellular available, you can use it. And what that permits is rules-based traffic routing. So you can define how I switch between the SATCOM links and the terrestrial link, is it based on latency or is it based on throughput or other business-driven rules based on lowest cost data routing? And now we're going to be able to extend that approach, right? So the next generation will include 5G along with now GEO, MEO, LEO, KU, and KA, so across all of those networks.

John Gilroy: Yeah, yeah. One ring to rule them all, one terminal to rule them all.

Ryan Stevenson: Absolutely.

John Gilroy: It was a vision 10 years ago, but who would've thought that even five years ago I thought it was almost impossible, that's fascinating. Ryan, I think you've given our listeners a real good idea of the innovation that's taking place in the area of antennas. It's really been fascinating. I'd like to thank our guest, Ryan Stevenson, Chief Scientist from Kymeta. Thanks, Ryan.

Ryan Stevenson: Thank you so much for having me on, John. I really appreciate it.