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EDITED TRANSCRIPT
VZ - Verizon Communications Inc at Barclays Global Technology, Media and Telecommunications Conference

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CORPORATE PARTICIPANTS

Ed Chan *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

CONFERENCE CALL PARTICIPANTS

Amir Rozwadowski *Barclays PLC, Research Division - Director and Senior Research Analyst*

PRESENTATION

Amir Rozwadowski *- Barclays PLC, Research Division - Director and Senior Research Analyst*

(technical difficulty)

head of the U.S. telecom services and communications infrastructure research practice here at Barclays. It's with great pleasure that we have with us today, Ed Chan, Senior Vice President of Technology, Strategy and Planning at Verizon, to discuss with us all things network related. So thanks very much for being with us here.

Ed Chan *- Verizon Communications Inc. - SVP - Technology Strategy & Planning*

No. Yes. Thank you for having me again.

Amir Rozwadowski *- Barclays PLC, Research Division - Director and Senior Research Analyst*

Fantastic, fantastic. Well, Ed, did you want to do a little safe harbor before we...

Ed Chan *- Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes, we do. Wait. That's funny. We have a bunch of forward-looking statements here. If you could go to our website, on our Investor Relations website, you'll find our safe harbor statements there. Some of those statements that I will make would be forward-looking.

QUESTIONS AND ANSWERS

Amir Rozwadowski *- Barclays PLC, Research Division - Director and Senior Research Analyst*

Fantastic, Ed. So again, it's great pleasure having you with us on stage again today. We've had the pleasure of discussing all things network related for some time now and a number of years. But perhaps for the benefit of those that have not had the chance to hear you speak in the past, can you provide us a little bit of color on your role at Verizon and some of the responsibilities that you maintain.

Ed Chan *- Verizon Communications Inc. - SVP - Technology Strategy & Planning*

I have the best role in Verizon. The way I see it, I get to pick on what I like to play with and pick out what the right technology path is. Just think of me as the -- what's the -- in telecom the chief network architect, so which means that my job is to plan the network on what technologies we should pick, how do we shift that to a digital future, what should the long-term plan look like. It kind of cuts across both products and networks and how we go to market in terms of how the digital technology looks like for the customer side as well.

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Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

Fantastic. And your, clearly, network leadership has always been a cornerstone of Verizon strategy. Do you believe that this is as important today as it has been in the past? In other words, do you think that network quality of service will be increasingly important in the future?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Thank you. I -- this -- this just had no doubts for me, as you know. I look at how we have come from the years past, all the way to now. And when you think about the way that the world is digitizing and the access to information is getting increasingly more and more important. And even today, as you look at even a few years back, you will say, "Does it really matter if your smartphone isn't working when you get -- landed to a new city?" You realize that the most beloved taxi-hailing application that you may want to use is going to rely on how you use it. Now back a few years ago, I would say, no I didn't even think that, that may be an actual application that runs on a network. So I would think that, as you move forward, as you see -- even the next industrial change, as we talk about AI and ML, right, some of the artificial intelligence that is coming to kind of the forefront of how we can become even more efficient, you'll see that the ability to connect and get the information and get the data to even process the AI information that's necessary to do so, you find that increasingly even more important going into the future. So it is very hard for me, Amir, to think that networks would be even less critical in the future when everything that we do is practically living in the cloud.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

Well -- and you guys think of stirring the pot a little bit about that network discussion more recently. Maybe we can dial into your 5G strategy a bit here. At the onset in this year, you folks had announced you were testing in several markets. And more recently, you started to shed some light in terms of what those tests have provided in terms of color. Can you talk to us with -- or provide us with an update on what you've learned from these initial trials, specifically what types of speed, reach, any other insights that you've had?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes. Even step back just a little bit about how we have come to this stage, even when we have first started looking into this a few years back, about, I would say, 4, 5 years ago. Some of you heard us talk a little bit about we need to densify the network a little further. So we actually had thought, even back then, that millimeter wave is going to start coming into the network for use. So we started designing or architecting the network to essentially figure out how to build this future with a multiuse fiber backbones, centralizing the radio network, and then ultimately, adding 1-mill wave into it. So when we shift this into 5G, we kind of knew this was coming. Now back then, people would tell you, "Oh, small cells. That's not going to happen." So now you're getting to a place where everybody is saying those things are actually true now. That is actually okay to go after and deploy the small cell in densifying the network, so you're now hearing everybody saying the same thing. But I think the same thing is happening with 5G philosophy. We started off a couple of years ago, saying, "Look, the standard is just way too far. The industry really needed a shift and a change faster." So 2 years ago, we -- a bunch of us together, including (inaudible), chipset providers, manufacturers for OEMs, for devices, as well as folks that has the network infrastructure, and we created a specification. And once that started, we took this to trial, like you said, this year and said, "Let's put it in front of actual customers, and let them tell us what does that look like." So I would say with that millimeter wave and the way in which we approached that particular trial was that very successful pieces that we found. I would tell you, as an engineer, it's a -- the basic stuff that we tested, 1,000 feet and below, most people will say, "Yes. We understand that. That works, and we all agree that, that would work." Then we start to say, "Well, would they work from 1,000 to 2,000 feet?" And we're pleasantly surprised that we also find those areas that it actually does work. And then we said, "How far can you push it?" So we were targeting the essentially gigabit services that we can get up to and see how far we can push that envelope. And we got it all the way out to 2,600 feet and be able to get at least a GB of services in that case. So there are a couple of things that along the way we found very interesting that engineers would always say, "The physics doesn't work. This is how it is." But I think sometimes we underestimate how much technologies can actually change the way in which you engineer systems like this, so there's a bunch of learning that you get from this. But the results that we get essentially is that the ability for the silicon to actually track the beams is no longer the same as we used to do in millimeter wave systems. So what we find now is that with what we thought was impossible thing, so would it even get past the -- any kind of trees and vegetation. Would they get through low-e glass. I'd give you one really weird example where we actually run into a home for an installation. And with the low-e glass, the big issue that everybody talked about. Well, yes. But low-e glass was a problem. We actually

put the system -- actually, the antenna right next to the low-e glass, and the system actually worked. So that's kind of the surprises that we saw that were different than when we went in. We originally thought that from an MDU standpoint, we can go as far as 6 floors. We got way up past that, up to the 20th floor, so there's a lot of these interesting things that we found that's going to be valuable as we move forward into the mobilities case as well.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

So it almost seems like if I was to distill some of the comments you've made that through these trials, the tech seems to be working better than you anticipated. Is that a fair...

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

It is. I would say that is a very fair assumption because I guess in so many ways, we are probably one of the most conservative engineering folks here -- out there. And I would say that we were probably more pessimistic originally when we go into the case, but it has -- that surprised us in many cases.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

Okay, okay. And then if I think about sort of what the next steps are, I mean, you folks have announced that you'd be launching in 3 to 5 markets next year. Perhaps that sounds like a small initial launch. Could you talk to us the decision-making process around those 3 to 5 markets? What is going to be attractive about those markets? And why aren't we seeing a larger sort of deployment?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes. So there are multiple things that play there. The process in which we went through and said, look, we took the results from that trial and then actually went and do the design characteristics of some of those markets and what it looks like. But the other thing that I would also say is that I've talked a little bit about the customer and how the digitization of the customer is happening. The other thing that we started to have to work with and something that's very valuable going into the future also is working with the municipalities. And generally speaking, too, we also need to make sure that we get the right municipalities to understand that we are coming to bring forth a digitization process also for the actual citizens of that municipality as well, not just for the sake of deploying just home broadband because the next step is the mobility case as well. So we wanted to go after a set of cities that we said, "Look, we want to make you a highlight, also for, I think, 5G cities." So we went through a process also to kind of combine between the economics of where the right density and the right places are and then also which municipalities may be more progressive in terms of bringing new technologies to the particular city. It's a -- I will say that the other thing that's pretty interesting is when we went through this process of engineering the network, what we find is that when we overlay our actual millimeter wave onto our existing 4G sites that I've mentioned that we've been densifying the network in so many places that you realize that it's an incremental addition. It's not a brand-new build for 5G networks. So coupling that concept and how we deploy is how we end up with the 3 to 5 cities starting in 2018. And with the -- obviously, the long-term view being that we want to get to the mobility case, so we'll shift into that second use case at that point.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

And one of the things that you'd mentioned was sort of it's not an incremental sort of expansion when it comes to the network. I think one of the things that came out of your 5G update was that you folks don't expect this really shifts the mix or -- maybe I shouldn't say mix, but it shouldn't really shift the absolute dollars when it comes to investing. Why is that the case? And what have you learned from the trials now in terms of densification that that's actually not the case?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes, so it's an excellent question. When we did the original thought and overlay, we took a very aggressive approach to say, "Hey, if it's an engineering that needs to work only at a couple of hundred feet. What would that look like?" And that does make the densification a bit higher than what we currently have. But once we went through the trial and figure out what it looks like and overlaid a new millimeter wave onto our existing -- essentially densify the network, we've figured out the fact that you could actually provide a very good coverage even from that perspective without having -- so we stopped getting brand-new sites into the network but changing our existing sites that we have, the base stations that we have and then adding 5G to it, and in the future, combining into 4G-5G network base station so that it actually serve both 4G and 5G. So that's why at the end of the day, the entire investment become a shift from 4G towards 5G as we move forward, rather than just a full expansion of just overlaying with 5G.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

And then you had touched upon the idea of ultimately looking forward to the transition to mobile.

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

It does seem like -- and perhaps, you can correct me if I'm wrong, it does seem like the standards organizations have picked up momentum.

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

How do you view that with respect to your own sort of initiatives to build out services starting in '18?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes, absolutely. It's -- actually, we -- one of the things that we've said is that because we've been so active doing the actual work out there, we were out there starting to talk to the chipset providers, like I said at the beginning, a couple of years ago and then actually demonstrating with the 11 cities that we trialed in earlier this year, it creates that momentum to actually drive. And most folks would know, if you go back and check, before we started actually doing work in the field for 5G, the standards body would be saying, "Yes. 2022, we'll get some stuff going," and they were imagining stuff to it too much. So for us, our perspective was let's get out there and build a network, and then the applications will come, because one of the additional new use cases, and we're just -- I was joking earlier this morning with folks about we didn't even think the smartphone stuff was here when we first launched 4G, if you think about it. So it would be practically silly for us to predict all of the applications that is going to show up for 5G. We know the first 2. We know that enhanced mobile broadband, we know that the home broadband, we know those things can be done. But the next steps of applications like AR/VR, and things along those lines will come, but we can't be the best person to predict that. But to go back to your point. When we drove this effort with all of the work with the different partners with us, you saw the acceleration. So what you will see is that this year, the actual mobility part of the standards from the radio perspective will be done. And at that point, you'll see the chipset providers start creating and printing chips, and you'll start seeing chips. And we see it even from Qualcomm, who announced that they will have chipsets available approximately a year from now. So they have announced something that they'll have next year.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

So what does that mean in terms of Verizon's own sort of network structure? I mean, it seems as though the pathway to a standards-based network build is a lot clearer than it was, let's say, a year ago. Is that an appropriate assumption?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

It is. It absolutely is. So I would say that we essentially see that there is now a clear path to massive scale with the standards body version, rather than just the standards version that we created. So now we know with the spectrum that we have, we're going to be able to actually shift over to the standards version next year. The other beauty is that with the 11 cities that we're in today, those become our what we call generally the standard and our base mobility test sites, and now they become test clusters for our mobility testing. So again, those learning that we'll get, not just from this U.S. trial, but moving forward, you're going to start being able to see now the engineering team is going to understand just what it will look like as we enter into the mobility space.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

So given that -- given that the timing of the standards have accelerated, and you mentioned the Qualcomm announcement. If I'm not mistaken, that was at millimeter wave, this chipset as well, and the assets that you have in place at the moment once the Straight Path acquisition closes, I mean do you believe that you have a sustainable competitive advantage in 5G at this point?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes. I look at it this way. I look at the -- going back to the architecture and what is necessary to deliver 5G, I looked at 3 different things. So from an asset perspective, the ability to have the multiuse fiber, the ability to have the dense network that we already started a few years ago and working with the municipalities all these years and then the ability to continue the 4G investment into the 4 pieces of what that looks like and combining that with the 5G technology. So the asset base, obviously, that sums back down to the spectrum. So from day 1, we always said that for 5G, it's not just an improvement on my existing spectrum. Everybody is going to tell you that my existing spectrum will become a 5G spectrum, okay. So that's a technical discussion of what that looks like because, at the end of the day, what we are describing as 5G is a wide band, a step-function change in the bandwidth that is provided to the customer. And so we talked about hundreds of megahertz of spectrum. So when we talk about that kind of need, you realize that you have to get up to the millimeter wave band to get to some of those, at least in the U.S. for the short term, and then we can off [man] and find other ones with the FCC at the mid and low band. But in the immediate future, the millimeter wave band is where you have this kind of sizable spectrum to do so. So on that asset base alone, I will say that, clearly, we have the right asset that I'm very happy with, that we can build a pretty good, sustainable, differentiated network from that base. And then combine that with the -- I will say the engineering learning that I talked about so that now we're ahead of it, you'll -- it's interesting that there are things that you'll find that are a little bit different than the traditional way of engineering the networks, so that will carry forward for us as well, and then finally, the consistent investment from a capital perspective that you asked earlier. I think when you combine those pieces together, I don't think there's a debate.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

Well, so one of the things that you alluded to was sort of 5G and other bands, right? But it feels like you folks have been leading the charge in terms of the discussion of millimeter wave for some time now, but we speak with global operators. I mean, there's a lot of folks that are talking about 5G's existence and sub-6 gigahertz side bands. And correct me if I'm wrong, but it sounds like you guys aren't opposed to that. Or what do you think about it?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

No. We're not opposed to that at all. I mean, it's kind of funny. I used to say it depends on what do we all want to be. Yes. I would love that hundreds of megahertz of spectrum in the sub-6 gigahertz, but you got to look at the industry and the actual country that we're in. And you look at the U.S., there isn't such a band available of sub-6 gigahertz today with any -- without any actual long-term action to relocate a lot of folks out of that existing use today. So that means that it's a timing of sequence issue. It means that the U.S. is not going to wait until such time when we can clear out the -- a few hundreds of megahertz of spectrum available for 5G to be used for us to actually deploy. So it means that we will deploy with millimeter wave and then come back and add on the other lower bands to it. But again, I will go back to the fact that, look, we are talking about not all of the bands that we have today, we have like 20-megahertz channels, when you combine them together, it will become 80, 100 megahertz at most. So I'm not talking about the fact that we're just going to make all of our spectrum today slightly better and become 5G spectrum. I'm talking about to deliver a high-band incremental, a much bigger step-function of differences, you need bandwidth that's bigger. So I -- that's why you don't hear me talk about the fact that all my spectrum is 5G today. They all will sound like they're 5G spectrum, but they're not going to provide the same bandwidth as we talked about in the millimeter wave.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

That's very helpful. And one of the other areas that we've seen a significant amount of innovation is in the core network, initiatives such as software-defined networking, virtualization, mobile Edge computing moving to this intelligent Edge architecture. Can you provide us with what -- any insight in terms of what Verizon has been doing to re-architect its network in that direction?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes. It's been a long journey there also. We've been calling it the intelligent Edge network. What's been happening is that we've been virtualizing, if you will, bringing a lot of the functions in the core network to software. But in addition to that, there's a lot of functional changes in terms of the software being the control point for the fixed assets. So the ability to control it in an end-to-end manner would be essentially to be able to help us automate and become a much easier way of doing it, but also sharing that asset. So we are essentially using one of the recent item that we created with this multi-services Edge platform that is actually software control, but the control point, the transport portion is actually common, but we have multiple brains controlling it. So that's the kind of function that that's going to make you a lot more efficient moving forward. So foundationally, it makes the core network shareable across different items. But the other thing that you brought up, what we believe the intelligent Edge network becomes is I'm going to now start looking more cloud-like in the core, but I'm also starting to look more cloud-like in the Edge to the -- all the way to the base station. So you're now starting to see us actually having these compute and storage capabilities all the way to the Edge of the network. And what gets really exciting is when you get to that 5G place and you add this kind of Edge-cloud capabilities, you started seeing the fact that, wow, would it be interesting that it feels like the cloud is right in your back pocket when the latencies got short, right, when the bandwidth is so high. Today, if you think about it, the cloud is quite a bit further away. The applications are run pretty far away. The bandwidth that needs to go to those data centers is pretty far. But if you -- all of a sudden, move that to the Edge and the latency characteristics where your phone can become more like a screen and just a lot of processing being done there, AR/VR becomes a real capability, no longer something you have to wear a backpack to do it, AR/VR exercise, that your phone can become one. So that's kind of how -- we believe that's kind of the way in which this intelligent Edge network where you can automate and also orchestrate across the end-to-end and provide this capability to create services in an end-to-end manner and combining that with the mobile Edge compute with the low-latency side of the network, it's going to be a very interesting space.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

But what does that mean for the cost of running the network? It seems like that could be a fairly significant reduction.

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes, there is. So we started driving some of those pieces because we had started converging, if you will, the core network from a converged core perspective and all different stuff, but the Edge is where most of these things are -- the stand is. So if you think about it, yes. There is a -- when you

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started sharing those, there's a massive cost advantage. When we used to have many, many different dedicated Edges, where there's routers or even the switches very specific for maybe a private network here, maybe for a public network there. Once you take that away, and say, "Look, I just have a single box, and it's controlled separately and automated," yes, it's going to be a very, very interesting way of running a network at that point.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

Excellent, excellent. And then we talk a lot about the future with you and thinking about the network and the network architecture over the next couple of years, but perhaps if I can pull things back a little bit. What is Verizon doing today to ensure that LTE network doesn't miss a beat -- what type of investments are you making in today's network? What type of new spectrum opportunity do you see to continue to augment the LTE network as sort of your initiatives around 5G ramp?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Yes. I would say the #1 -- it's actually very interesting when I say we have a very broad network from the very beginning. So when we -- when usage shows up, we actually find that at different time of days and also different geography, a network of our size actually can take on those capability and demand much easier than maybe a spot-based network. But more -- even more importantly is that we've been seeing so many technology changes that's always been, I will say, practically undervalued in terms of the stuff that you're bringing in. So as an example, we started testing what is called Full-Dimension MIMO, but these are 64 antennas for 4G alone. I'm not talking about the one that I show last week with 1,000 antenna in the 5G in a single box with a pretty small size. And in those kind of cases, you see that technology stuff is changing. But from a spectrum standpoint, we've been working very closely with the FCC also to try the CBRS-shared spectrum. I've always said this as an industry, I mean, the spectrum is one of the most valuable resources for the country. And for us to not use some of those are pretty silly, right. So we need to help drive that entire ecosystem also to bring the CBRS spectrum to use as well as some of the unlicensed spectrum. Well, you know what, we've been driving this as well. So you see those things starting to come along with additional new pipes of spectrum, all of the LTE Advanced features that needed the Dark Fiber and the architecture that I talked about earlier, that's going to start kicking in this year and into the future as well. So 4G is actually -- from a 4G LTE Advanced standpoint, we still got a long ways to go from the technology innovations that I'm seeing. So it's very interesting.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

Excellent. Now I know we've hit on time. One last question on my end. If you were to leave our audience with one key takeaway and how we should think about Verizon's network strategy, what would it be?

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

I will say we go back to the very beginning where we truly believe that the customer is going to be relying on the network more and more into the future. So we believe that with that kind of critical use that the customer is going to be needing, we believe network reliability and network capability is going to be critical to that. So that's number one. But I would also say that we are the doers. We want to be out there actually creating a market and creating this new feature for the customer, so that we're not just sitting back waiting for something to happen or just waiting for the next set of standards, but being out there driving it. With consistent investment, we believe that we have the right assets that I talked about earlier, that we'll be the one that's going to be leading the market investment.

Amir Rozwadowski - *Barclays PLC, Research Division - Director and Senior Research Analyst*

Excellent, excellent. Well, we wish you the best of luck. Thanks very much for being here.

Ed Chan - *Verizon Communications Inc. - SVP - Technology Strategy & Planning*

Thank you, Amir. Thank you.