Qualcomm Incorporated
Executive: Cristiano Amon
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Announcer: Please welcome to the stage, Qualcomm's president, Cristiano Amon.

Cristiano: Good morning, everyone. Thank you very much for coming to Qualcomm's MWC 2019 press conference. Please be patient with us today. We have a lot of announcements to make. It's going to take a little bit of time, but 5G is going, you know, everywhere. And, we're trying to take that in expanding our product portfolio. We're also very excited about this MWC 2019. This is the MWC that a lot of things have happened for this new transition of wireless called 5G. And I'm very happy to be here with you today, and we have a lot of interesting things to share. And no t-shirts today, huh. Don't forget to follow me on Twitter. I'm trying to keep a lot of updates on what's happening, and yeah, I would appreciate some extra followers too. So, appreciate that.

So, with that, let's just start what we call the invention age. We have this transition in the industry, and it's very profound. It's not hype. It's more profound than what we've seen before with the 4G transition. And it's going to be the biggest breakthrough for Qualcomm and for our partners in the wireless industry.

When you look at what happened in the industrial revolution, it was about electricity; coal and electricity. Then Internet and digitalization and digital transformation ushered the information age that we are right now. But 5G will enable what we call the invention age. 5G is basically going to connect us to the cloud and connect everything else. And this is how we think about the role of our company for the next 30 years. For the past 30 years, not to use the Nokia tag line, but we've been connecting everyone. And basically, now we have the ability to take the scale of mobile into everything else. And with that, and the transformation to 5G, we'll have a period of accelerated innovation that we call the invention age. And this is the age that we're going to see the development of two technologies side by side. We've been saying this at Qualcomm, and I want to go back to the 4G transition just to give you an example and comparison.

Qualcomm is a company focused on creating standards and solving technology problems for wireless. In the 4G transition, it was very clear, especially as we get into a discussion of use cases, that mobile broadband requires you to have a computer in your hands. That's no coincidence that we were the first company to have GHz clock speed on a mobile battery powered processor. And we saw advancements in digital signal processor, graphics and multimedia. And that's why the smartphone platform in the Snapdragon were created. It was created as we needed to develop mobile computing side by side with 4G broadband.

As we get to 5G, we're going to be connected at unlimited speeds, unlimited data consumption. More like electricity, to the cloud and with reliability. And in the

data lakes, in the data, you know, analytics, it's going to evolve side by side with 5G. We're seeing today in our chips the fastest growing silicon area is AI processing. And that's going to be the era of 5G in AI. Billions of connected things, enormous amount of data and then we're going to see the need of the cloud moving to the edge. And that's a very important transition in the industry and AI will develop, enabled by the 5G connectivity like we saw mobile computing developed side by side with 4G.

And 5G is here. It's here in 2019. This is the year of launch. 5G was originally scheduled for 2020 and Qualcomm, with many of our partners that shared the same vision for the mobile industry and the desire not only of the industry but consumers to see innovation faster. We have accelerated 5G to 2019. And this is the year that we are starting to see incredible devices, incredible commitment on operators in launching the network and we're going to start to see new services. The deployment is beginning around the world. I'll make a comparison. I want folks to remember that 4G was launched in 2009, about ten years ago. And I will talk to you later today about how did we see the situation then and how we see the situation now. But what is different is we're starting with mobile phones but as you've seen during the press conference today, the potential is way beyond smartphones. And it is going faster than ever before to other industries. So, this is the year of 5G launch, and we're very excited to be here at MWC for a large number of product announcements.

When we look at the transition of 5G, I want to go back to 2009 and compare what happened to 4G in the first year of launch. In the first year of launch, and some remember Verizon Wireless was the first operator in the world to build at large scale, a 4G network. In that year number one, we had four operators, three OEMs. Fast forward to 2019, ten years later. What do we have right now in the year of the 5G launch? We have over 20 operators that are already announced and they are building the networks. We have over 20 OEMs, 30 devices. It's almost a 10X difference on the device side of what we've seen with 4G. So, I think for a lot of the skeptics, it's very clear to Qualcomm that the 5G transition will be faster than what we have seen from 3G to 4G.

5G devices are coming. They are not uncompetitive. They're not bulky. They're not power hungry. And a great example of that is what we had last week, an amazing launch of our partner Samsung, of the Galaxy S10 5G. At this show, we saw for the past two days, a number of other devices also launched and announced from companies like Oppo, Xiaomi, LG, Sony today, and we expect to see more devices before the end of MWC.

5G deployments in the United States, Europe, Japan, Korea, Australia, in China, using both sub-6 and millimeter wave are ongoing and we're working to further develop the standard. So, there's a lot of activity. There's a lot of excitement and

energy, and we're going to make this 5G transformation. But rather than hear about that from me, I think we'd like to hear about someone who is deeply involved in the 5G rollouts with a great display of leadership in bringing this technology to life through their customers. Please join me in welcoming to the stage, Johan Wibergh, the group technology officer of Vodafone. Thank you so much, Johan, for joining us.

Johan Wibergh, Group Technology Officer, Vodafone: Thank you very much for having me. And I think Qualcomm is a great partner to us. And we started some six years back, in R&D and standardization discussion on what 5G should be, what can we bring to our customers. And I think it was about three years back, I had the discussion with Cristiano, and a few other companies, about accelerating and bringing 5G to the market somewhat earlier, and that's why it's coming to the market in 2019. I think it's been a great leadership show by Qualcomm and a great, great partner.

So, in Vodafone, that we started about two years back doing trial and testing on 5G. About 18 months back we introduced this called, massive beam forming in our 4G network. And at exhibit here a year ago, we were showcasing live outside exhibit on how well the technology was performing in the live commercial network. Actually, the people walking around outside know that they were on a massive MIMO 4G base station delivering traffic giving excellent performance. And then yesterday, we did announce that we have a precommercial network live here in Spain. We have 11 base stations live in the downtown of Barcelona. And we are riding a van around there getting on average, one Gbps throughput. We are using eight MHz of spectrum or Band 43 so on the sub-6 bandwidth we have here in Spain. We peak around 1.7 Gbps. Now of course, there are not that many customers on that network right now, so it's fairly good, easy to get good peak performance, but we do believe that we are going to be giving our 5G customers about 10 times, on average, the performance to get them at 40 today. I think that's a good mindset to have, about ten times the performance.

So, in the last two years, we've been running in the four countries of Europe, various amount of testing, to make sure the technology matures and working with our key network vendors, with our key handset partners, as well as with Qualcomm to make sure we learn and mature the technology. And we then said yesterday that we will be bringing the technology to our customers during the second half of this year. So, I think finally, we start to see that 5G is becoming real.

You may ask yourself, how difficult this is to bring it to the market, what does it mean for an operator. And one advantage we have at Vodafone, is we did a big modernization of our network around 2014-2015. 98% of our cell sites here in Europe have what's called, [single] RAM. It's one base station that supports all

2G, 3G and 4G. And so, you just need to add on the 5G new radio, and in some cases, you change the baseband in the base station. So, it's an easier process compared to when Cristiano was talking about the launch of 4G. I was part of that. It was much more complicated. It was a new complete base station you put out there. You had your two base station, your three base station, your four base station. It was much more hard work to get 4G up. Now it's just adding it on. It's a simple process. So that's really good.

At Vodaphone, we have a strategy to have a leading performance on our network that we provide to our customers, a gigabit performance. So, I really hope our customers will be happy with the 5G experience we are going to bring.

Maybe as a final word, I would like to say that for me and for Vodaphone, the 4G era has really been the era of the smartphone. And 4G really brought the smartphone out to the market and really made everyone's usage. I think on 5G, we will start with smartphones as some of the first use cases, but I do believe the 5G is going to be the era of IoT. Vodafone today, we have 80 million devices rounding our IoT global platform. And I do believe that the capability that we now can have with the mobile network, everything from narrow band IoT up to the capability on 5G, will create a lot of new usage, a lot of new use cases for IoT. And ten years from now when we look back on this day, we're going to say, this really started the era of IoT.

Once again, thank you, Cristiano and back to you.

Cristiano: Thank you very much. Thank you, Johan. Thank you. By the way, it's such a pleasure, I think, at Qualcomm, and for me personally, to have Johan here with us. It's the right person and to be here talking to us about the launch of 5G in 2019. As Johan said, we were also working together in his former position at Ericsson for the launch of the first 4G network. And I think as he said, we learned our lesson, 5G is going to be much faster this time. So, thank you again, Johan. Thank you for the great Vodafone leadership and for being with us this whole time in accelerating 5G. Thank you.

So, moving on, this is the year of the Qualcomm Snapdragon 855 5G. We have now 30 design wins, on the 855 mobile platform Snapdragon, for 5G devices, and it's been the right processor that exceeded all industry benchmarks, from mobile performance, to connectivity, to gaming with Snapdragon Elite camera, and it's going to have, at the same time, the leading AI capability in the industry. And consistent with the Qualcomm vision, this is where 5G and AI will go side by side. It has our fourth generation Qualcomm artificial intelligence engine with Qualcomm Hexagon Tensor accelerator, and it's two times faster than the nearest Android competitor. So, we're very proud of our team working on the 855, and I think a lot of the products that you've seen, announced in Barcelona with real 5G

happening right now, is with 855. That's why I've probably been busy for the past couple of days, and I have a lot of other t-shirts that I'm going to display for the rest of the week.

And we're making 5G a commercial reality in 2019. So those are the different parts of the world that this is launching. And I'll try to answer the question; when can you get one, when can you get a 5G 855? And devices are going to arrive in the second quarter of this calendar year around the world. So, in the next quarter, we'll see devices. Many of those announced at MWC, available to consumers and to enterprises in North America, Europe, South Korea, China, Japan, Australia and Southeast Asia. And what is different this time is we see all regions launching at the same time. We have a mature smartphone market today, and there's a clear understanding of the benefit, which I will walk you through later in the presentation that users will be able to see, and their smartphones with 5G. And of course, we're going to talk about more today, what's happening on the Android ecosystem in 2019.

And I wanted to use this press conference and that's our first announcement of the day, to bring to light, one thing that we've been saying. And no matter how many times we say it, we still get the same question; that 5G devices are going to be inefficient and they're going to be power hungry. I want to talk to you about that, with today's announcement of Qualcomm 5G Power Save technology. It's a comprehensive solution that, and this is a statement, we are not going to launch any 5G device without, on Qualcomm chips, without this capability. And this is the feature that will allow a 5G user to have all day battery life on their smartphones. As we've been saying, this transition is going to be faster. The networks are prepared for a faster transition and we're making sure the devices are created for a mature smartphone user. Users will not change their 4G smartphone if they don't have a device that looks good, it has the capabilities that they expect to upgrade, and has an all-day battery life. Qualcomm is building this technology on a mix of standard and unique Snapdragon capabilities. On the standard, we use connected mode, and this continues reception C, D, or X which is a feature in the 3GPP standard. We combined that to a number of unique techniques and capabilities, that set us apart as a system company, not a traditional semiconductor component company. And with that, we now have, for the early devices, the same battery life that you see on Gigabit LTE devices. This technology is supported on all the launches with Qualcomm Snapdragon 855, and the X50 5G modem, as well as the X55 modem that got announced last week. And those modems are going to power the first wave of launches, and they are all going to come in with all day battery life for our users. So hopefully, this is the much-awaited capability that will probably put to rest the industry concern about battery life.

Moving on, when you look at the top applications that are going to be in everyday smartphone, and as the applications most used by the smartphone users, we're showing what the capabilities are going to be on those existing use cases for 5G. And very consistent, what you heard from Johan, the download latency is significant. When you look at Sub-6 GHz networks, you're going to see a 3X improvement up to a 20X improvement when you look at the millimeter wave networks. On content download the speed, and that's the most transformative of the user experiences on the smartphone. Also download, but we can talk about upload later. It's 3X to 10X improvement. And then when you think about video, today you can see that about 4% of the content is playback on your smartphone at the maximum bit rate of the content. With 5G, 95% of the time, the video content will be on the maximum bit rate. So, what you heard from Sony in their launch today, is about the capability of content creation but also the capability of video consumption. Video will be as easy as streaming music. And we will have a fundamental change how we think about broadcast, especially for live content. So, users will see a significant upgrade in performance for the existing apps, and of course, there are going to be a lot of other applications and services that will leverage the 5G capabilities.

And as we think about that, you should expect that as we launch 5G on the Android platform, it's a great opportunity for this platform to take advantage of this technology and bring amazing services and experience to the Android users. And instead of you hearing that from me, I would like somebody to come up on stage who knows a thing or two about applications and services on Android. Please welcome to the stage, Vice President of Marketing for Google, Bob Borchers. Welcome, Bob.

Bob Borchers, Vice President of Marketing, Platforms & Ecosystems, Google: Thanks Cristiano.

Cristiano: Thank you so much for joining us.

Bob: No, my pleasure. Thank you.

Cristiano: Industry is a very small place and also coincidence. Besides working with Bob in his capacity at Google, Bob and I also know each other. We are on a joint board of a bank, the largest retail bank in Brazil. And you are going to think about it, you know, what are the Qualcomm guy and the Google guy doing in a bank. That's a great example of mobile changing every other industry, especially the banking industry. So, I've known Bob for a long time now. We've been working together for a long time, and I could not be more excited to have a partnership in Google as we bring 5G to Android devices in 2019.

Bob: Yeah, excellent. And thank you, Cristiano. And it is great to work in now another professional capacity together. And of course, we're excited that Android is the

first and, at the moment, the only OS that is powering 5G smartphones and really driving this revolution forward. And we're excited to be a part of the vibrant ecosystem together with Qualcomm. It's really a unique opportunity. But it shouldn't be surprising. It's a unique opportunity that is built for a platform like Android. The platform was created by its very nature, for moments like this. For the industry to move forward as an open platform with a complete ecosystem. And it allows for a rapid development and commercialization unlike other platforms that maybe need to be in kind of a different environment. And ultimately, we believe that Android is the foundation for moments for launch of things like 5G and other industry changing events.

But of course, great technology needs great creative people to explore and invent the experiences that consumers are going to want and desire. In this case, I'm really excited about the partnership between Google and Qualcomm and the thousands of developers on the Android platform, and I'm just excited to see what they come up with their inventive minds. And while we're starting to see some interesting applications show up and I'm sure there will be many more.

Cristiano: So, Bob, I think the question that everybody wants to know, what are the apps that excite you most, especially as you think about the potential of 5G?

Bob: Well, I may be a little biased. At this moment in time, we've got a number of things going on with AR that I think are tremendously exciting. And in fact, for all of you here, you'll notice that for the first time, our famous Android pin lock is happening in AR. And I can only imagine what that's going to be like next year, when this is all lit up with 5G, and everybody has those devices, and we have even richer, more fulfilling, more immersive experiences coming to life.

Now, a lot of that is built actually on the partnership that we have using the neural network APIs and the work that Qualcomm has done to allow app developers to build faster, smarter and smoother AI experiences, built for 5G. Of course, I think thinks like video chat, gaming, AR, all these are exciting areas of opportunity. But ultimately, it's going to be up to the developers. It's going to be up to this vibrant ecosystem that's represented here and around the world to see what they come up with, with their creativity. And I can only imagine, and I'm sure that they will do things that amaze us. We, at Google, develop in a mobile first environment, and we serve billions of customers every day. And we're hard at work imagining what that future can be like in a 5G environment. And we're looking at figuring out ways to take our applications and really build them and leverage 5G to its fullest. But it's, bottom line, we're super excited to be here at Mobile World Congress and celebrate this key industry milestone with everybody here. And Android, together with Qualcomm and other ecosystem partners, I think really are going to reinvent the future. So, thanks for the opportunity.

Cristiano: Thank you. We're really excited to work on this with Google. It's a great opportunity, I think, not only for both of our companies but for the developed markets and our many partners. Thanks again, for joining us. Thank you, Bob.

Bob: Thank you.

Cristiano: Much appreciated. I can't wait to upgrade my Android device to the upcoming 5G, and I think, you know, the opportunity and the head start that we have with Google in 5G, it's an amazing opportunity for innovation, and the mobile industry welcomes innovation. We're very excited about that.

And then, I wanted to get to this. After this whole conversation, I wanted to get to this part of the presentation. And this is, we wanted to get all the way here. When we started on this journey back in '17 and the beginning of '18 when we were all working on the acceleration, I wanted to get to this slide at MWC 19 and show the proof points of what we've been saying. And we've been talking about making the impossible, inevitable. So here is what was said about 5G. And there's two people saying it; 5G smartphones will be bulky, they'll be uncompetitive, there will be no mainstream 5G launches, there are not going to be the flagships, it's going to be a one-off device for demonstration and prototyping purposes, the battery life will be poor, mmwave will not work in a mobile environment, it's going to come in later, it's going to be difficult to put the antennas, it's going to have hand positioning issues, this technology will be immature, it's all about Sub-6 and then 5G smartphones won't be available in 2019. That was the message. When you look at what we were able to create, the combination of our X50 modem, the 855 Snapdragon platform, the Qualcomm 5G millimeter wave antenna modules, and the power save technology, here's what we were able to accomplish, and I want to point to Verizon Wireless 5G new radio launch, with millimeter wave technology day one, and the amazing Galaxy S10 5G that got announced last week. And this is the ecosystem created, and it hopefully answered every one of those questions about the success of the 5G transition, we're going to start right now in 2019 with devices in consumers' hands in the second quarter of 2019. And we're very happy and proud, not only for the work of Qualcomm but the entire ecosystem, to make this happen.

And with that, we're going to go to the announcements that we have today. I will start by recapping what the announcements were that we did last week about the X55. It's the very first 5G multimode modem. It's an intergraded multimode modem with every single mode of wireless connectivity. It is the very first announced, 7 gigabits 5G modem, and it is the industry's fastest. I'll take a moment to make an observation. This modem supports 7Gb downlink and 2.5 Gb LTE. It has the ability to support 7 Gb. Some of our competitors, as they wanted to claim the fastest modem, they would be adding up the capability. So, no matter what criteria you use, X55 is the fastest 5G modem in the industry. It supports

every single capability of 5G, from not only NSA mode and SA standalone mode, but also TDD and FTD. It builds on the 5G leadership, and it's paired with our first multiband 5G millimeter wave antenna module which is eight millimeters thick. And this second generation that got announced, the QTM 525 millimeter antenna module, it's going to create unbelievable devices. And it is the world's first envelope tracking capabilities for PA and for power in 5G adaptive antenna tuning solutions which is 100 MHz wide. So, we're very happy with the ability, not only to launch 5G with the X50 and 855, but also start sampling to our partners our second generation, our second generation 5G chipsets with a single multimode modem before our competitors are shipping and commercializing their first 5G product. And, I think that's what you will probably expect of Qualcomm in any new transition of wireless.

Now, the next announcement and this is what we are very proud and hopefully will feed into everything that we're talking about it. We're not stopping there with two chips in 2019. We're also announcing our very first mobile platform, Snapdragon with integrated 5G in a single die. It's a fully integrated MSM with 5G which is designed to accelerate the global adoption of 5G going beyond flagship smartphones to large scale 5G smartphone for all geographies. In this next quarter, as X50 and 855 reach its consumers, we'll be sampling to our OEM partners, our third generation 5G chipsets. And you're going to see devices now, in the first half of 2020, with the fully integrated Snapdragon.

So here is the recap; we're launching 5G in Q2. We're moving to our second generation multimode X55, and then when we get to 2020, at the beginning, where 5G was supposed to launch, we're already going to mass volume 5G with an integrated Snapdragon SOC. And we're very happy about that.

But we're not the best company to talk about devices. So, as we're going to talk about devices, I would like to welcome to the stage, the industry leader in mobile devices, the real industry leader. Please welcome Dr. June Hee Lee from Samsung. Thank you so much for coming to the press conference. Thank you.

Dr. June Hee Lee, SVP & Head of Technology Strategy Team, Samsung Elecronics: Thank you. I'm so glad to be here with all of you today at Mobile World Congress. Over the past decade, Samsung has worked with technology leaders from around the world to pioneer innovations that make our lives richer, our communities stronger, and our businesses more successful. At Samsung, we believe open collaboration is the key to putting new innovations like 5G into the hands of the consumers. Our partnership with Qualcomm has been crucial to building the foundation for a reliable high performance 5G network. I'm very proud to be here. One of the first to congratulate them on their launch of their integrated 5G platform, and we look to introducing a device on this platform in the near future.

It's been nearly 10 years since the jump from 3G to 4G. Each year, our mobile devices become more powerful, more useful and more essential. What seemed impossible ten years ago is ordinary today. 2G took the telephone off our desks and put it in our pockets. And 3G and 4G unplugged the Internet from our desktop PC and linked it to the phones in our pockets. For the first time, we could work from any location, shop any time, and communicate using image and video instead of voice and text. 5G will take us further through the power of broadband wherever we go. And Samsung has been at the forefront of taking 5G from cutting edge concept to reality.

Early on, we conducted 5G trials with the largest telecom carriers around the world. Throughout the trials, we made incredible breakthroughs. We validated the real-world performance of 5G in mmwave spectrum. We made the first 5G international video call from Minneapolis, and so, we complete the work for a successful data transmission using 800 MHz bandwidth in the 28 GHz spectrum. And we were the first company to receive commercial authorization from the FCC for our 5G solution.

Last week, we reached our most important milestone when we announced Galaxy S10 5G, Samsung's first 5G smartphone, at the unpack. Galaxy S10 5G builds on our leadership in designing network solutions from network infrastructure to devices. After years of trials and testing, we are putting the most advanced network innovations directly into the hands of consumers to deliver the fastest speed available on the most powerful smartphone feature set on a Galaxy S line device. Galaxy S10 5G running on a 5G network unlocks entire new possibilities. The speed to download a season of HD television series in minutes and load websites and apps in the blink of an eye. The buffer free experiences to stream your favorite TV shows, movies, sporting events uninterrupted. And the bandwidth to break through the congestion of high traffic network at a crowed concert. It's here. It's now, and it is a defining moment for Samsung and the industry. And, we are excited to continue making progress towards unlocking the full potential of 5G with upcoming products from Qualcomm.

Here, at Mobile World Congress, we are excited to see what the future will bring for mobile connectivity through 5G. But the opportunity isn't just ours. The ecosystem that really matters isn't just the one we've built within Samsung. It's the one we are creating with carriers across the world. As well as the device manufactures and the software developers, we share our vision for technology that puts people first. Partners who are working with us to put the power of innovation and creation in their customers' hands. The speed will feel like magic, but it's not just the speed. 5G changes everything because what it means for latency and device density. In a moving car, latency becomes the difference between stopping in sub-centimeters or meters. The difference between safety and disaster. There's no way to overstate how important these things are. This is why 5G is the key to

autonomous driving. It is the foundation for vehicle to everything communications that will connect your car to every car, traffic light, street sign and road sensors on your route.

5G is the key to smart cities. It is the foundation for sensor network that will monitor air and water quality, streamline public transportation, and improve public health and public safety. 5G will unlock the potential of virtual reality and augmented reality merging the real world seamlessly with virtual objects allowing you to engage in real time with the physical and digital world simultaneously. And 5G will revolutionize how we play games. Cloud based gaming will bring multiplayer console style, graphic rich games with virtually no lag. We're truly excited to show you the possibilities of 5G at World Mobile Congress.

At the Samsung and Qualcomm booth, you can feel the power of 5G right in the palm of your hands. With our VR experiences, you can be one of the first in the world to experience 5G.

Again, thank you very much and please join us at the Samsung and Qualcomm booths to see the future in action. Thank you very much.

Cristiano: Thank you so much, Junho. Thank you so much. It's really great. We're really excited, especially with our collaboration with Samsung. Thank you, Dr. Junho. Samsung is going to be the first company to work with Qualcomm on the Snapdragon integrated 5G SOC. But most important, this is a relationship of over 30 years. No matter how many people try, nobody can really separate Qualcomm and Samsung, especially when you talk about advanced technologies and innovation in mobile. Let's make a change together, Dr. Junho. Very excited about that.

So now we're going to talk beyond phones, into the opportunities that exist with 5G to support new deployment models of this technology. So 5G, it will change the landscape, as well as empower both public, as well as private networks. And that's another metric why the 5G transition will be faster because the densification of the network will be done in parallel by the operators, and the enterprises, and the industrial companies, as we look at the private and public applications. And that will provide a performance and capacity for a large number of applications and services that make use of the speed, the latency, the edge computing, and the cloud connectivity of 5G. And the ultra-low latency and the high reliability will support everything for industrial automation to reconfigure both factories and flexible manufacturing. And that is going to create a whole new paradigm. It's not a perfect comparison, but we like to simplify the conversation by comparing the telephony transition from the central office and the PBX. And when you look at the enterprise, with its own PBX and its Wi-Fi network, as we think about the 5G future, the enterprise deployment of 5G will get 5G in many places way faster

than we've seen in any other transition of wireless. And that creates whole new opportunities in business models for our carrier partners and for the many companies that will transform their business with mobile.

And when we look at the connectivity, we see this changing not only at the manufacturing and industrial sites, which we will talk about that today, to a great extent. But we're going to see that also changing the home, and changing the office, and the enterprise for productivity. As we have the ability to bring cloud computing and edge computing to 5G devices, we redefine productivity where you will be able to have on demand processing using 5G connected to the edge cloud to be able to bring different use cases to compute on devices. You know, of course it will change the PC. Which it is in transformation as we look at the cellular for always connected and cloud connected computing productivity device. And as we look at the deployment opportunities, we also see the small cells playing a much bigger role than it had played before in the wireless industry.

And with that, we're making another announcement today. In a partnership with the newest operator in Japan, Rakutan, we're accelerating the future 5G network using small cells. The collaboration with Rakutan is providing an end to end cloud native 5G mobile network, using Qualcomm small cell silicon. So Rakutan is building their 5G network in Japan, using the Qualcomm FSM and we're very excited to see what we have, you know, set ourselves to do in the past, looking at the potential of small cell, starting to see this come to life now at a very large scale for a 5G network. And we're very happy about this partnership with Rakutan. We know the responsibility we have to support them building this network, and I think that's going to give enough scale for the small cells, and we're going to see that also, this exact model, propagating to a lot of private and industrial 5G rollouts.

We also understand the new opportunity that 5G has to provide fixed broadband, fixed wireless broadband with 5G, especially as we look at the low latency, and reliability, and the discussion we have about video. It can be a replacement of broadcast networks, as you have the reliability to provide live in sports, 4K content in addition to broadband. So, because of that use case, for many of the operators, we are announcing today that we now have the ability to support CPE equipment with our 5G chipsets delivering the high-power performance that is required for fixed wireless. And I'll be a little bit technical. When you think of smartphones, the maximum power that you can get on smartphones is a little over 20 DBM. Our chipsets in CPE mode, will have power up to 40 plus DBM and that creates a completely different economics. As you think of the link in 5G for the fixed wireless use case, which is also complimenting a lot of the operators 5G rollout and applications. And we're announcing that capability as part of the X55 chipset.

And as you think of the connectivity, this is also an area that Qualcomm sees the potential of Wi-Fi 6 working side by side with 5G. And we're also announcing today, a whole new product; our QCA 6390 is the world's first SOC of Wi-Fi 6 for mobile devices, and a design for the industry leading performance for smartphones, and PCs with Wi-Fi 6, and get paired side by side with the Qualcomm 5G Snapdragon platform.

So that's how we are thinking about the deployment opportunities, about connecting the enterprise, connecting the home, upgrading cellular to 5G, Wi-Fi to Wi-Fi 6, and make this as part of an ecosystem. And at the same time, you know, making small cell solutions available for all the new deployment models. And we're very excited, and we're just starting to begin the next phase of the 5G transition on the network side.

And mobile is impacting everything. That's the power of mobile going to other industries. And Qualcomm is doing that with mobile, going not only to networking as we talk about today but also mobile compute, XR, the automotive, and IoT. And that opportunity is only going to multiply and expand the TAM for our company and our partners as we launch 5G. And as part of that, we have the most exciting roadmap of technology that we've seen in every generation of wireless. As we're driving the transition to 5G new radio, and we start with innovations in Release 15, and we build new use cases such as mmwave for outdoor and indoor, and we look at the capabilities of boundless XR, I want to invite everyone to watch this at the Qualcomm booth, which is the ability to use 5G as a link to the edge processor and basically run workloads on your smartphone SOC that we never thought was possible as you tap in to unlimited computing on the other side of the 5G link. And then deployments with massive MIMO. But we're working hard to bring Release 16 and other releases which you unlock a lot of other opportunities. It's the evolution of Sub-6 is the long awaited industrial IoT ultra-reliability. We are demonstrating in the Qualcomm booth, at MWC 19, 6x 9s of reliability using 5G new radio, 99.9999 which is industrial ethernet capabilities that can connect any mission critical devices. And we are going to bring 5G to automotive with cellular V2X, and the evolution of shared and unlicensed spectrum will allow the private network deployment. So, this roadmap will move faster.

When we look at what happened to LTE, we started with LTE for service of 100 Mbps, and we've been nonstop every quarter or couple of quarters, bringing more speed and now we have up to 2.5 Gbps LTE. The transition we're going to see in 5G, as we bring new industries, will be much faster. And Qualcomm is committed to continue to work hard to be the first with every new standard of 5G. It's a moving target, and the goal will be, when we have this press conference one year from now, it will be to show all of the capabilities of 5G and all of those other industries delivering further on the 5G transition promise.

And as we think of the opportunities beyond phone, of course, we will announce as we get to our new chipset, a Snapdragon for computing. The 8CX, the most powerful Snapdragon to date, designed specifically for the Microsoft PC, we're announcing today that we have a 5G capable connected PC. It's the extreme battery life that you've seen on the always connected PC but now with 5G connectivity. And this will help the deployment of the enterprise 5G network using small cells. And we'll be able to see this story together as we bring connectivity to the enterprise PC. And we're very proud today to announce that Lenovo, the world leaders in the enterprise, announcing with Qualcomm that they're building the 5G PC with 8CX. And this is now really going beyond phones, and we're very excited to have that transition.

To share more about the always on, always connected PC and the enterprise, we thought about bringing here, somebody that is going to be not only fully invested on this with Qualcomm but also very qualified to tell you what they are doing in their own enterprise. Please welcome to the stage, Renee Haas, President IP Products Group from ARM. Thank you, Renee.

Renee Haas, President of IP Products Group, ARM: Thank you very much. Thank you, Cristiano. Buenos Dias. Bienvenidos a Barcelona. My mom told me Spanish class would pay off someday. So, I'm really pleased to be here on behalf of ARM. Thank you, Qualcomm. Thank you, Cristiano.

We've been working with Qualcomm and Microsoft for quite some time on the Microsoft PC platform as many of you know. A lot of work has gone into application development, optimizations, work around the platform, having it work inside the enterprise. When Windows 10 was launched about a year and a half ago, and the always on PCs came out, we were really, really excited to see that happen. And we thought probably the right thing for us to do as an enterprise was to not only validate that our work with Qualcomm and the ecosystem was going to deliver a great experience but actually have ourselves use the PCs as a team. So, a few folks on the executive team, myself, my boss, we actually took hold of the very first units and started to use them. And I have to say, it was quite a transformative experience. Personally, I live in London. The ARM office, as many of you may know, is in Cambridge and that's about an hour train ride from central London. So, I thought, I would give it a go in terms of using this device which has a connected, at that time, 4G LTE modem. And for those of you that have used the rail system in the UK, you may know that the Wi-Fi experience is not optimal in terms of connectivity and reliability. But got on the train, used the system and literally, as the Wi-Fi would drop in between tunnels, it would snap over to LTE automatically and I still had constant connectivity. Really, just like how your smartphone works. Additionally, close the lid, get off the train, go to the office, open the lid again and you're back in the same state that you were. And very quickly, I came to realize that the experience that I was having with this

machine was akin to what I was having on the smartphone, which is actually what you want to have.

You know, other examples, we've had folks who have worked with these machines. They'll take them on a flight from Tokyo to San Francisco, eight hours. True story, and this is my boss's story, worked on the flight the whole time and was still at 80% battery life upon landing. These are the kind of machines that you can leave your power supply in the office, at home. Cristiano used the word extreme a few times. They are absolutely true to that advertisement. The performance is fantastic. The battery life is fantastic. And it's only going to get better.

So, as we go forward into 5G, 5G is going to not only enable an amazing amount of use cases, in some of these other areas like IoT and virtual reality, but when you start thinking about, what does that mean for a PC experience, it gets very, very interesting. You know, whether it's video conferencing, whether it's other types of applications that can be enabled, we really don't know. And if you think back a few years ago to 4G, Airbnb, Uber, these were not applications we ever knew about in terms of what they spawned. So fast forward, we think 5G for the PC experience is going to be able to enable a whole new set of applications in areas that we just can't imagine. We're super excited to be involved in it. We're definitely all in, as Cristiano said. I personally have been working on this experience for many, many years. It's come to fruition. It's real. You can book meetings, calendar updates. Everything just works. The application compatibility issue is something of the past. I think the future is really, really bright. We're super excited to be working with Qualcomm and the ecosystem on this and thank you again for having us here.

Cristiano: Thank you for coming, much appreciated. So, there's more announcements. You've probably seen also, the HoloLens 2 VR headset from Microsoft. As those things become mobile, of course they had to upgrade the platform. So, we're very happy to be partnering with Microsoft for Snapdragon 850 on the HoloLens 2. It's a great example where mobile devices are headed, and we are very happy they chose the Snapdragon 850 for that device.

Also, collaborating with the ecosystem to create XR viewers 4 to 5G smartphone, and it's going to bring next generation connectivity to mobile XR experiences. We're going to get to sleek and lightweight headset form factors from AR and VR experiences, and I think we are going to finally see the market opportunity develop for those devices. 5G will fundamentally change the ability to create content and will fundamentally enhance the experience. We've been committed to XR since the very beginning, and I think we're starting to see the devices now getting to the point that the opportunity will develop. Also, don't forget the role that those devices will play in industrial as we go to the industrial 5G transition.

Now, there's been a lot happening in the automotive segment. The automotive, it's mobile. It's inherited mobile. And it's been transformed by connectivity. And as we look at the connected car opportunity, we see a very bright future for technology. And technologies like, not only 4G and 5G for connectivity but also precise positioning for lane level accuracy and then the cellular V2X technology.

And we're doing another set of announcements today for the automotive platform of Qualcomm. We've been working hard not only the digital cockpit transformation but also in the telematics with the connected car. We are announcing today, the latest addition to the Qualcomm auto portfolio. I remind you, that at CES we announced a multi-tiered Snapdragon platform for the digital cockpit. What we are announcing at MWC 19 is the next generation connected car platform. It's going to be the industry first 5G multi-seam capabilities and the latest 4G portfolio of technologies with integrated cellular V2X. So, we are also going to have the ability to bring the multi-gigabit level connectivity for rich in vehicle experiences, lane level navigation accuracy, and vehicle to vehicle and vehicle to infrastructure safety. So, the reference design for this platform is available now for many of the auto customers, and we're going to see as fast as we've seen the adoption of 4G for the connected cars, we'll see the adoption of 5G and cellular V2X. And please check the cellular V2X demonstration at our booth. We're very excited about this technology. It's getting a lot of traction. And as you would expect, the Qualcomm new connected car platform, it comes with our integrated RF front-end, an application processor for cellular V2X, security, and Qualcomm vision enhanced precise positioning. So automotive has been a very bright spot for Qualcomm. As we bring mobile, and we help many of our auto makers make the transformation of the car with connected services, and digital cockpit, and we're very excited now to bring this mainstream for safety with integrated cellular V2X.

But then, the next big opportunity is the industrial IoT. That's a scenario that takes full advantage of the throughput availability, flexibility, and the scalable of technology in 5G and the factor of the future will be wireless. It will be connected with machine learning. It will be monitored, and it will be optimized. Many sensors creating mission critical data, connectivity of manufactured robots, head mounted displays, will provide a completely different smart factory business model.

And today, we also announce the Qualcomm robotics RB3 platform which is a comprehensive offering for the future of connected robotics. It supports AI engine. It supports the frequency for private networks, and it's being upgraded later this year with 5G capabilities. But to support the industrial transition, we announce a research collaboration with an industry leader, Bosch. And the focus is to bring 5G New Radio technology application for industrial IoT.

To talk to us about that, I would like to invite to the stage, Andreas Mueller from Bosch, which will talk about that collaboration. Thank you, Andreas. Thank you so much for coming.

Andreas Mueller, Director IT and Innovation Management, Bosch: Thank you, Cristiano. Thanks a lot. Good morning, everyone, and thanks for having me. It's a pleasure to be here. I just arrived from the airport a bit late, but it's good I was just in time and to show that we at Bosch know very well what just in time means and especially just in time in production, of course. And I'm really happy to be here and to talk about one of the hottest topics in the context of 5G from my perspective for the coming months and years. And as Cristiano said, this is 5G for the industrial IoT.

And the reason why we at Bosch and the manufacturing industry as a whole, is so much interested in 5G is because 5G enables us to support the transition from the factories of the past to the factories of the future. Now, a factory of the past looks a little bit like this. So, this is the Bosch factory 100 years ago, a spark plug production. You can see it's a lot of manual labor. It may not be a place where you would like to work.

Nowadays, of course, our factories at Bosch look a little bit different. So, this is a current factory here in Blaichach, in Southern Germany. It looks very different so it's much more automated with many machines and so on, but the basic principal is essentially the same. So, we designed and developed one product like this, not as beautiful electric screwdriver, and then we built up a production line which is highly optimized for this particular product, and then we used it again and again and again.

So, production used to be very static, very optimized for one product, but it's not what you want to have in the future.

So, in the future, driven by the globalization and higher use of demands and so on, we needed a much higher flexibility in production. We have to support a higher degree of customization, and that's why we came up with our vision of the factory of the future, which looks a little bit like this here. So now our vision of the factory of the future evolves. The ceiling and the floor of the factory are static and fixed and everything else is mobile, flexible, and can be easily reconfigured. So, you can see now, there are mobile robots, for example. There are automated guided vehicles taking care of the flow of goods and material on the factory floor. The monetary devices. And these are all individual modules, but of course have to be orchestrated in order to do something meaningful. And that's why we have to look at what do we actually need to realize this vision of the factory of the future.

Of course, if everything is mobile and flexible, we need wireless connectivity and we need wireless connectivity with a very high performance, so that's why I was very happy to hear the 6x9s that we can see at the Qualcomm booth because that's

exactly what we need for the industrial IoT; very high reliability, very low latency.

We also need edge computing. So, you can see here, our edge cloud so that we can shift intelligence from the end devices to below the cloud, like a programable logic controller, cloud controller, robotic controller or so. So, this doesn't have to be on the device anymore. It can be locally in an edge cloud.

We also have a very high demand for accurate information about a position of different devices. So indoor positioning is a very hot topic, as well and we are a very happy to see that this comes along with 5G in an integrated manner.

And last but not least, in industrial IoT it's not just one use case with one set of requirements but with many different use cases with a very diverse set of requirements. And in order to support all these use cases at the same time, we need quality of service differentiations, so we have to be able to run different applications with very diverse requirements at the very same time over the very same network. And it's also what 5G can do. So, if you look at all these features, and these are just some selected examples, that's all that 5G promises to provide. And currently, we only see 5G of the technology of choice that can actually satisfy all these requirements, and therefore, for us, 5G has the potential to become the central nervous system of the factory of the future.

So, what really matters about 5G, and I already mentioned some of these things, but here are some key aspects listed which we consider to be very important and really enable this great potential. So, first of all, it's about private networks. And also, Cristiano has mentioned this in his talks. So as a manufacturing company, you don't want to rely on public network for a production sensitive data, so it has to be isolated somehow from the public network. We need private networks, or one public networks, as they are called in 3GPP now. We need to add reliable low latency communications. So, Cristiano mentioned the 6x9s, the one millisecond latency and so on, so all the boundaries of what 5G can offer, that's all needed for manufacturing.

We need the quality of service guarantees, and it's not just about average values. It's about worst-case values and also this is something that we see in 5G. We very like the current developments time sensitive networking support in 5G. So, time sensitive networking will be the next generation of industry ethernet technologies, basically. And it's currently being standardized in 3GPP so that the 5G systems supports TSN, time sensitive networking in a native way.

And last but not least, it's about positioning. Sort of where information, where things are in a factory is a very relevant information, and if it can be integrating into the existing network infrastructure, it's a very big thing.

So, there's a lot of potential in manufacturing considering 5G, but it's also the other way around, in our opinion. So, for my personal perspective, and I'm not the only one sharing this, the industrial IoT really can become the killer application of 5G. Of course, we will see 5G in every smartphone, but the question is, can we unlock a lot of new revenue potential, and the answer is probably not because it's a saturated market, and it's just a better technology, but no one is really willing to pay more.

Now, if you look at manufacturing, it's different. Currently, the market is nonexistent yet, but it will develop very quickly. If you consider that there will be one private 5G network in a factory in the future. And then even in Bosch, we have more than 280 factories worldwide. So, we could become a very big network operator to some extent. But that's just Bosch. If you look at all the factories worldwide, there are billions of them. And it means there is a potential to have millions of factory networks, of more public 5G networks and all these factories. Of course, it's not just one firm with their device. There are many devices that need to be connected and therefore, it's a really a huge business potential. And therefore, the industrial IoT indeed may become the killer application for 5G.

In addition to that, it's a very highly controlled environment that makes it easier to satisfy the very demanding requirements that we have, and economic potential is really huge. So, if you can manage to increase the productivity by just 1%, and it's not something completely unrealistic, then we are talking about economic potential out of billions of dollars. So, it's really a huge market potential.

So, what does it take to unlock this potential? It's a very close collaboration between the two different worlds which are coming together now. So, on the one hand, the ICT domain, so with players like Qualcomm being very familiar with 5G technology and driving the whole devolvement. On the other hand, the OT, the operational technology domain, with companies like Bosch so we know very well what it takes to build up a production line, to do industrial automation and so on. And that's why we have established a 5G alliance for connected industries in automation in April last year. So, it's a new global alliance to bring all stakeholders together. Qualcomm and Bosch are proud members of 5G-ACIA. But alone, it's also not sufficient. So as Cristiano said, we are also very excited that we started a bilateral research collaboration between Bosch and Qualcomm to bring both competencies together so the leading knowledge of Qualcomm towards 5G and in experience and knowledge of Bosch regarding industrial automation and OT.

And one example of a thing we did already that we started to do joint channel measurements. So, everybody knows more or less, very well, which channel in a building like this what it looks like, but in a factory, it's a different thing. There's a lot of metal. There are many machines and so on. So, a good understanding of

the channels in a factory setting are still missing. And that's why we did some channel measurements in one of plants in Germany. It started to develop a channel model for industrial automation, and that's basically, of course, for everything so that we can simulate our systems and we can evaluate the performance and optimize it at the end of the day. It's just the very beginning so we're very much looking forward to the next steps together with Qualcomm.

So that's it from our side. And, with that, back to you, Cristiano.

Cristiano: Thank you very much, Andreas. Thank you so much. Thank you, thank you. Much appreciated. I have to say that we're very proud and humbled by this partnership with Bosch. And it is very clear that we can see the story coming together as you look at the capabilities of 5G, the use case in industrial, the private and public networks for industrial, the small cell architecture in the connected devices. And I want to repeat that this is going to be a much faster transition of a technology that we've seen before because of the potential of changing many other industries.

So, we get to the end of our presentation, and I basically want to say, 5G opportunity will be massive. That's the reason we say, the best years of Qualcomm are ahead of us. And Qualcomm technology is uniquely positioned to be a leader in this area for the investments that we are making. Hopefully, we will be able to show you today that despite doing the myth busters on 5G mobile, by basically challenging this skepticism with a sleek flagship devices, not one but many, launching with 5G in 2019, we also see an enormous opportunity going to 5G PCs, integrated cellular V2X and 5G connected cars, the transition of a network with a lot of dense deployment of small cells and what we will be able to demonstrate the build out of a large scale with Rakutan using our small cell silicon technology, and then the use case going beyond the enterprise to the industrial side. That's why we are excited about 5G. It's not about just the phones at MWC 19; it's about showing everything else that we're doing in parallel. And I think that's the mission of our company. As you know, we're just fighting for rights to innovate, continue using technology to transform industry and create ecosystems.

Thank you very much for being here with us today. This is just the beginning of what we call the invention age. We have a lot more announcements at the show today. I won't cover them all but please check because there are lots of things going on, and we're starting to see a lot of engagement from many, many industries and the technology that we can provide. And please, don't forget to check our booth to see a lot of the demos. I think now, we have time for Q&A. So again, thank you very much for coming and appreciate the support to the Qualcomm press conference. Thank you.

Question: So, you just showed off a whole bunch of use cases for 5G, some of which seem curiously like Wi-Fi. So, can you explain specifically why, for example, in some of these industrial IoT, why you can't use Wi-Fi in those situations?

Cristiano: Very good. I think one important, a very important and especially not only in the industrial but also on the enterprise, is 5G does not necessary replace Wi-Fi. Those two technologies are going to coexist side by side. But 5G has capabilities that are not available on Wi-Fi. Examples of that is, not only the lower latency but the technology that's being designed to enable industrial applications from a reliability standpoint. It is the first time that we actually have the ability to use a wireless radio system in mission critical capabilities that you can only do in the past with fiber. And you have the ability to leverage techniques on the network side, especially with capabilities like network slicing that allow you to treat different use cases with absolutely different priories and service levels. And I think that's where you start to see applications. In the industrial it's outlined by our partner Bosch but also, you know, things that you start to see on the automotive sector as well.

Question: What exactly is 5G Power Save? I mean, I saw you mentioned discontinuous reception and a number of new capabilities. Could you maybe touch on the latter? And then also do manufacturers, do they have to kind of do anything to, is it just out of the box? And then the third question, you kind of mentioned the third generation 5G modem that's been integrated and stuff. Is that the X55? Is it all new technology?

Cristiano: Excellent questions, thank you. Let me address the first one. So, the Power Save, as I said, use CDRX capability. But we also had the Qualcomm secret sauce. There has been – we are in a unique position now that we do have the ability to take a system level approach. You know, we've been working from the digital all the way to the analog to the antenna. And we've been doing a lot of different techniques for power implementation, and it's going to be, from any OEM as part of our release of the platform, they don't have to do anything. It is part of the testing and interoperability we are doing with all the infrastructure vendors and all the different releases that are going in the field for the multiple network providers. And you know, I think folks told me not to quote the improvements, but you should see that the – if you have an opportunity to measure some of the launches that are going to happen without the capability and the launch with the capability, you'll see deltas way north of 30% or more. And that's the reason we've got that confidence that we'll be able to launch 5G with an all-day battery life. Because at the end of the day, that's the minimum bar for you to drive a successful upgrade on a flagship.

Your second question is about the Snapdragon SOC. It's another modem. So, we're not going to unveil all the details of the chip at this time. It's going to come

in, we're sampling to customers next quarter, and you should see more news coming from Qualcomm. But we've been busy at work, and I think that's one of the unique capabilities of Qualcomm is the ability to do multiple modems in parallel and that's what we're doing right now.

Question: Which part of the world do you see fastest growth coming for 5G devices in the next five years? And the second thing I want to know, we switched from 4G to 5G in ten years. How much time do you think that the next big step will take, 6G?

Cristiano: Very good questions. So, I'll start with the first one. So of course, and you asked in the next five years. So of course, the biggest transition we're going to see and it's going to be the transition of smartphones is going to happen first. And in practical terms, when you think about that is the market is going to again grow at double digit rates. You know, it's a mature smartphone market right now. Mostly what you see is replacement cycles and upgrades. We're going to see a faster upgrade to 5G, double digit growth. And it is going to be a big growth opportunity for Qualcomm financially. It will get, at the very end of this physical year for Qualcomm that we're going to see the ramp. But, you know, as we look at the last quarter which is our first quarter 2020, we're going to have a 5G Christmas, and we're excited about that.

But then you asked me about five years, and I think the opportunity as we get the full potential of 5G, with the deployments on enterprise and industrial, you're going to see the new markets becoming even more relevant and they're going to grow fast. I think we have been saying as Qualcomm diversifies our business, going to growth markets, those markets are growing at faster rates and we expect that to accelerate in 5G in five years. I think a great example is there's just one single example on smart factory that Bosch presented today, you can see the potential of that technology for those new use cases.

Then your last question was bout the carrier migration. One thing is what Johan said, the carrier migration is likely going to be faster based on the architecture of the networks. But the best answer to that question is, if you look at a pattern, I'm just looking at smartphones alone, not even like the different use cases, smartphone alone, if you look at a pattern of average data per user per month, this is growing on a quarterly basis. And the 4G technology does not scale. At a certain point, it is significantly cheaper to deliver unlimited data rates using 5G. That's going to be a big economic factor.

One think that we've been telling the analyst community, and you are going to start to see that. You can go check that for yourself. I will point you to two examples that are already available right now. One example, I think, was the announcement made by Telstra in Australia. If you buy a 4G Galaxy S10 Plus, when the 5G is launched, you get a free upgrade. They just announced that at the

show. And so I think what you are going to see, the carrier incentive mechanism is going to get heavy users and users on the unlimited data rates to a 5G device as fast as possible and that is going to do a migration from 4G to 5G faster than what we have been seeing on 3G to 4G just because we have a mature smartphone base, and everybody is using a lot of data. There's not a lot of Blackberries and feature phones anymore and that's the difference.

Question: Several countries including Russia do consider 4.5, 4.99 Gbps band for 5G networks. Do you think that the network equipment for these unusual band as available as 3.4, 3.8 Gbps spectrum?

Cristiano: Yes. I will provide a provocative answer. I think what we are saying to the regulators worldwide, resistance is futile, allocate everything to wireless. So, because you are going to have not only the launch on, for example, Sub-6 and 3.5 or on band 41 in the case of China, in the United States 2.5. But you're going to go after all other frequencies like we saw what happened in 4G that we have 65 bands and counting. And I think the technology is going to be abstracted both on the network side, but more important, what we are doing on the front-end side so that we can bring scale abstracting that from the device manufacturers integrating all those bands.

And I just want to finish that answer by saying, one great thing about the Russian market is also the deployment of mmwave that is part of the 5G launch. So, I think we are going to see not only those frequencies but also the millimeter wave frequency as well in that market.