Sarah Cremin

From: Sean Bolger <Sean.Bolger@imaginegroup.ie>
Sent: 14 March 2019 11:03
To: Public Accounts Committee
Cc: Derek Kickham; Brian O'Donohoe
Subject: RE: Correpondence from the Public Accounts Committee
Attachments: PAC 5G Fixed Broadband Reference Sites and Documents.pdf; 5g.co.uk What is 5G.pdf; 5g.co.uk What is 5G Fixed Wireless.pdf; Lifewire 5G a replacement for Cable US.pdf; Lifeline 5G Fixed vs 5G Mobile (002).pdf; UK 5G transformed from hype into reality.pdf; Erricson 5g Fixed Wireless Access alt to wireline.pdf; Erricson Fixed Wireless Access Economics.pdf; Smasung who-and-how_making-5g-nr-standards (1).pdf; UK Government Networks of the future full fibre and 5G.pdf

Categories: Red Category

Eilis

In response to the request from the committee see attached

1. "PAC 5G Fixed Broadband Reference Sites and Documents"
   This provides the links to the various sites and documents
2. For convenience copies of relevant sections, documents and articles in PDF

Can you please confirm receipt of same.

Apologies for the delay in getting this to you.

Regards

Sean

From: Public Accounts Committee <PAC@oireachtas.ie>
Sent: 25 February 2019 10:26
To: Sean Bolger <Sean.Bolger@imaginegroup.ie>
Subject: Correpondence from the Public Accounts Committee

Dear Mr Bolger,

Please find attached correspondence from the Public Accounts Committee.

Kind regards,

Éilis Fallon

Éilis Fallon | Committee of Public Accounts
Houses of the Oireachtas | Kildare House | Dublin 2 | D02 XR20
T: +353 1 618 3074
https://www.oireachtas.ie/

Beartas ríomhphoist an Oireachtais agus séanadh.
http://www.oireachtas.ie/parliament/ga/eolas/beartasriomhphoistanoireachtaisagusseanadh/

5G Fixed Broadband Reference Sites and Documents:

For the benefit of the Committee see below the following reference sites to provide a better understanding of 5G and in particular 5G Fixed Wireless (5G Fixed Broadband) as an alternative "last mile" solution to deliver future proofed highspeed broadband services.

For assistance I attach word and PDF versions of the articles and documents.

The following ref sites and documents provide a good overview of 5G in plain language**.**

www.5g.co.uk Is a good basic reference site with guides to the relevant topics

https://5g.co.uk/guides/what-is-5g/
See attached
https://5g.co.uk/guides/what-is-5g-fixed-wireless-access-fwa/
See attached

Article 5G Fixed Broadband an Alternative to Cable in the US (Copy Attached)
https://www.lifewire.com/5g-internet-wifi-4156280

Article explaining the difference between 5G Fixed and 5G Mobile (Copy Attached)
https://www.lifewire.com/5g-fixed-wireless-fwa-4178934

https://www.techradar.com/news/the-week-that-uk-5g-transformed-from-hype-into-reality
Article on 5G in the UK

Industry Reference Sites

https://www.ericsson.com/en/networks/trending/hot-topics/fixed-wireless-access/5g-fixed-wireless-access
Erricson's view of 5G Fixed as an alternative to Fixed Line

Fixed-Wireless-Acces
s-An-Economic-Study

Erricson Economic study on 5G Fixed Broadband as an alternative to Fixed Fibre Networks

who-and-how_makin
g-5g-nr-standards (1)

This is a good overview from **Samsung** of the standards (Speed and Capacity), capabilities and availability of 5G
Copy Attached:

UK Government Digital Strategy

https://www.gov.uk/government/publications/uk-digital-strategy/uk-digital-strategy

This is the link to the UK Governments Digital Strategy which reflects the importance and joined up approach to a **Fibre and 5G strategy** and not Fibre in isolation.

"Networks of the future: full fibre and 5G

We have to encourage the market towards ubiquitous ultrafast services but balance the additional benefits of increasing speed against the costs today of providing the infrastructure. Government has an important role to play to accelerate and de-risk the deployment of the next generation of digital infrastructure - setting the structures; supporting experimentation and testing; helping to reduce the costs; and above all for leadership and setting ambition. At Autumn Statement 2016 we made a clear commitment to digital connectivity, including the allocation of £740 million from the National Productivity Investment Fund to support the market to roll out of next generation digital infrastructures."

https://www.ericsson.com/en/networks/trending/hot-topics/fixed-wireless-access/5g-fixed-wireless-access

5G fixed wireless access

How FWA will massively scale with 5G

 Hot topics

- Fixed Wireless Access
- 5G fixed wireless access

With the evolution to 5G, Fixed Wireless Access (FWA) offers a path to deployments on a massive scale and better services for customers.

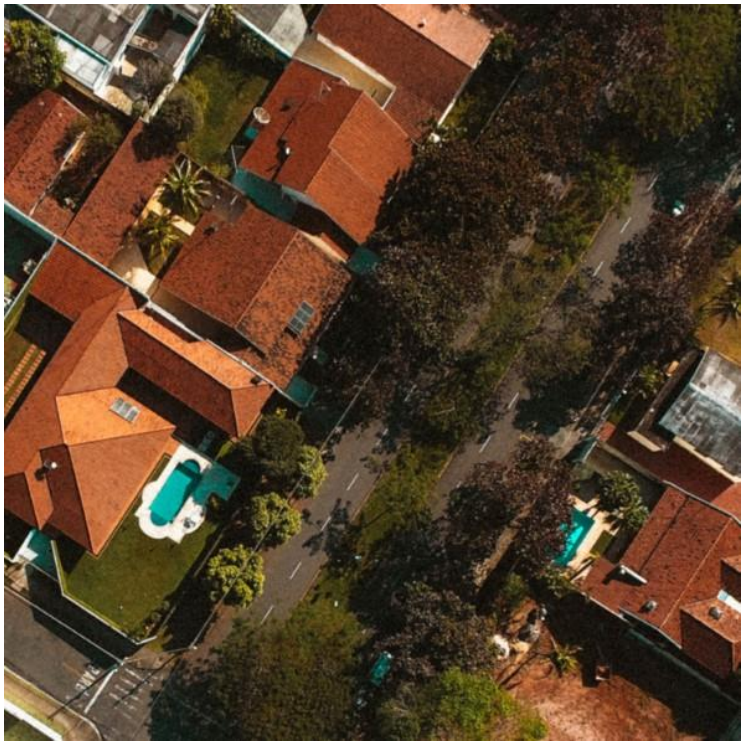
5G FWA changes the economics of connecting homes and businesses

Today, there is already a strong business case for using FWA as an add-on improvement to mobile broadband (MBB). FWA is particularly attractive in areas where there is no existing copper, fiber, or hybrid infrastructure to deliver wired broadband, or when the current fixed infrastructure is unable to provide sufficient service.

The business case for FWA only becomes stronger as LTE continues to advance to 5G. One of the 5G use cases currently gaining momentum around the globe is using FWA to provide broadband service for homes and small and medium-sized enterprises (SMEs).

With the help of 5G, Fixed Wireless Access will grow on a massive scale

With 10 to 100 times more capacity than 4G networks, 5G will enable cost-efficient FWA deployments on a massive scale. Using larger ranges of radio spectrum to provide consumers with low latency connectivity (1ms) and major capacity gains, the evolution to 5G will take FWA to a whole new level.



Fixed Wireless Access on a massive scale with 5G

5G will enable cost-efficient FWA solutions on a massive scale, with 10 to 100 times more capacity than 4G networks. Using larger chunks of radio spectrum to provide consumers with low latency connectivity (1ms) and major improvements to capacity, the evolution to 5G will take FWA to a whole new level.

5G FWA is an attractive alternative to wireline solutions

The bulk of the cost involved in fixed access deployments (as well as much of the complexity) is associated with the "last mile" portion of the network that reaches the user premises. Compared with fiber-to-the-home (FTTH) and other wireline solutions, FWA offers a variety of benefits, including significantly faster service rollout, lower rollout costs and lower OPEX.

Build for the future with 5G FWA

5G FWA is expected to enable robust services at sustainable rates high enough to meet the needs for residential use well into the future. 5G FWA will not only eliminate the need for costly deployment of deep-fiber fixed access infrastructure, it will offer peak rates that few fixed technologies will be able to match.

https://www.lifewire.com/5g-internet-wifi-4156280

5G Internet: The High-Speed Replacement for Cable?

5G Wi-Fi could be the best option in some areas

Updated March 06, 2019

If you want fiber-like speeds without the cost, or high-speed internet in an area that doesn't currently provide it, then 5G Wi-Fi might be something to look into.

While it isn't available everywhere quite yet, there are several reasons to consider using 5G at home when it does roll out in your country.

5G Wi-Fi in the context of a 5G network is not the same as 5 GHz Wi-Fi supported by some routers. See 5G vs 5 GHz Wi-Fi for an explanation.

What Is 5G Wi-Fi?

Similar to how you get Wi-Fi at home right now, either through an existing wireless service like microwave or satellite, or a direct wired connection like cable or fiber, 5G is be able to deliver internet to your home via a direct *wireless* connection.

5G Wi-Fi is simply Wi-Fi that's providing internet access from a 5G wireless network. The way this works is through fixed wireless access (FWA), which is a base station that wirelessly connects directly to an end-user's location, specifically to a fixed wireless terminal (FWT) on the premises, like your home or business.

Once internet service via 5G Wi-Fi is at the home, for example, your existing Wi-Fi router (or a new, special router) provides internet throughout your house just like it done now.

Why Get 5G Internet?

5G Wi-Fi could be a good idea for a number of reasons. For starters, it'll be *really* fast — at a minimum theoretical speed of 20 Gbps (2.5 GBs) per cell, it's set to be over 10 times faster than 4G and most likely faster than many types of wired home connections.

5G Speed: How to Understand the Numbers

Another aspect is the extremely low latency standard that 5G networks are required to abide by. This means that everything you currently do on the internet will be a lot faster, like downloading files, sharing data, uploading videos, online gaming, movie streaming, etc.

All of your devices could connect to the internet without suffering from congestion, video buffering, random disconnects, and other bandwidth related hiccups, meaning even more

bandwidth demanding devices could be used at home like virtual reality headsets, augmented reality apps, etc.

5G is also capable of reaching people in areas that don't have the existing infrastructure to provide reliable internet, or internet at all. This could be anywhere that wired access is unavailable like in rural areas, new construction sites, developing countries, etc.

Another benefit to 5G Wi-Fi is its reduced cost. Lots of the expense related to network infrastructure, especially high-speed technology like fiber, is the hardware between the provider and the home or business. For traditional wired networks, this means *lots and lots* of cabling and other equipment, most of which goes away in a 5G Wi-Fi system.

5G mobile providers will be able to offer massive improvements to existing fixed broadband (FBB) providers, so it's possible that this competition could lower FBB costs or provide existing FBB customers with comparable services to compete with 5G providers.

Why Is 5G Better Than 4G for Wireless Internet Access?

Most service providers are implementing 5G networks using higher frequency bands than what's used for 4G. This opens up room for more traffic on the network, which translates to greater speeds and higher capacity networks, to deliver everything described above.

5G also provides greater focus than 4G. What this means is that the radio waves provide a concentrated beam that can directly target specific users for ultrafast speeds on an as-needed basis, exactly what you want with a wireless internet service at home.

5G vs 4G: Everything You Need to Know

When Will 5G Wi-Fi Be Released?

Verizon is currently the only carrier that offers 5G Wi-Fi, but it's only available in a few cities. Read about their Verizon 5G Home broadband service for more information.

You can't get 5G Wi-Fi everywhere just yet because not all companies have upgraded their infrastructure to support 5G technology. Its release date depends on many factors, including your location and service provider, but most are looking at 2020 to be the year 5G really emerges as the next big mobile networking technology.

See When Is 5G Coming to the US? for more information on when Verizon, AT&T, and other providers are planning to implement 5G networks in your area. Others can get an idea for when 5G comes out in their country here: 5G Availability Around the World.

https://5g.co.uk/guides/what-is-5g/

You might have heard the term 5G being bandied about more lately and be wondering what it is and what it means for you.

But wonder no more. In this article we cover everything you need to know about 5G, from what it is, to how it works, when it will arrive and why you should care.

What is 5G?

5G is short for 'fifth generation mobile networks'. And that's literally what it is – the fifth generation of mobile networks (with a mobile network being what you use to call, text and – when not connected to a Wi-Fi network – get online). But it's set to be far faster than previous generations, and unlike 4G it could open up whole new use cases for mobile data, which we'll get to below.

A little historical background demonstrates the context of 5G. First-generation networks were introduced back in the 1980s – they were analogue and only carried voice. In the '90s, 2G (or second generation) phones launched and they were digital, introducing new features like text messages and picture messages. The early noughties ushered in 3G (third generation) which started to include video calling and mobile data. Ten years later we saw 4G, and these networks and phones were designed to support mobile internet and higher speeds for activities like video streaming and gaming.

Now, networks are changing again and 5G is set to land soon.

When will it arrive?

How soon is soon? Some countries such as South Korea, China, Japan and the US are claiming they will launch 5G networks later this year (2018) or early next. However, in the **UK rollout isn't set to begin until late 2019 or 2020**, according to the government's 5G strategy and statements from network operators.

Even then, that's just when networks will start to roll out 5G, so we might not see widespread 5G coverage in the UK until 2022 or later.

But there's a chance some networks will be slightly ahead of the game here, as for example EE said in February 2018 that 5G was just 18 months away, meaning a live UK network could exist from late 2019.

What is the current situation in the UK?

Because the amount of spectrum available is finite, it has to be allocated. Ofcom, the UK's communications regulator, has begun a 5G spectrum auction to help cope with demand.

This auction will see 40MHz of spectrum in the 2.3GHz band and 150MHz of spectrum in the 3.4GHz band auctioned off, with the former being useable now and the latter being earmarked for 5G use.

The auction is likely to be completed in or around April 2018, at which point the UK's mobile networks will be much better equipped for 5G.

However, even with this additional spectrum the UK's mobile networks will probably want more, and Ofcom plans to address this with a subsequent auction of spectrum in the 3.6GHz-3.8GHz and 700MHz bands.

But that's just one aspect of preparing for 5G in the UK, as relevant technologies also need to be developed and trialled, which is happening now.

For example, O2 will run a trial at The O2 arena and visitors will be able to try out 5G and see demos of virtual reality, augmented reality and live streaming applications. Another trial is running in Bristol to demonstrate futuristic media services such as personalised augmented reality city tours.

EE has also carried out a 5G trial in its labs, achieving consistent download speeds of 2.8Gbps.

The findings of these experiments and others will be used to ensure networks are 5G-ready for 2020.

Of course, many developments will also happen outside the UK, and these will be vital too. For example, China's Huawei is driving many 5G developments.

What benefits will it bring?

The main benefits of 5G are expected to be that it will be much faster – some are saying as much as 100 times faster.

Top-end 4G networks, known variously as 4G+, LTE-A or 4.5G, can deliver peak download speeds of 300Mbit/s. By comparison, 5G promises to offer speeds in excess of 1Gb/s (1000Mbit/s), with many estimates placing it closer to 10Gb/s (10000Mbit/s).

To place that in context, you will be able to download - not merely stream - a full HD movie in less than 10 seconds on a 5G network. The same task would take closer to 10 minutes on 4G.

Network type	Download speeds	Time to download a full HD film
3G	384Kbps	Over a day
4G	100Mbps	Over 7 minutes
4G+	300Mbps	2.5 minutes
5G	1-10Gbps (theoretical)	4-40 seconds

It will also have **much lower latency**, which means you'll see very little delay or lag when you do things on your phone or other device – we are talking milliseconds, which are undetectable as a user.

That will help not just with existing things such as online gaming, but could also be vital for things like self-driving cars, where any delay could be the difference between life and death. You can see how 5G latency compares to current latency in the table below.

Network Type	Milliseconds (ms)
3G Network	120ms (actual)
4G Network	45ms (actual)
5G Network	1ms (theoretical)

Further, 5G will also have **greater capacity**, meaning the networks will be able to cope better with many high-demand applications all at once – from connected cars and IoT (Internet of Things) devices to virtual reality experiences and simultaneous HD video streaming.

All of this should add up to you having a fast, stable connection wherever you are and whatever you're doing on your phone. There's more too.

Real-world examples/impacts

For starters, you'll be able to download films and games in seconds and watch them without any buffering. We're also likely to see new applications using **virtual and augmented reality**. For example, you might see satellite navigation projected onto your car windscreen, or targeted adverts projected onto windows.

We'll likely also see **even more IoT devices** such as phones, fridges and lights all connecting to one another. The Internet of Things is starting to take off anyway, but with the speed and capacity delivered by 5G we might one day see almost every device become 'smart' and connected.

However, network operators claim that 5G isn't simply another network upgrade but represents a "revolution" that could enable applications and services which benefit society.

For instance, experts say that 5G is **fundamental to autonomous cars** because they will need a constant, guaranteed connection. Similarly, we might start seeing drones delivering our goods. 5G will be essential for other 'critical' scenarios too, such as remote surgery, with doctors controlling medical robots from across the world, and automated factories.

Industrial equipment could also be controlled remotely, increasing worker safety, and **holographic video** could become a reality, allowing for 3D medical imaging and more.

O2 has recently forecast that 5G will save us significant amounts of time, including £6 billion a year in productivity savings in the UK. The report finds that 5G-enabled tools such as smart fridges, smart grids and electric autonomous vehicles will save householders £450 a year through lower food, council and fuel bills.

Optimised services, driven by the likes of **smart bins and intelligent lighting**, could save councils £2.8 billion a year too. Further, the analysis suggests that because 5G will enable wider use of **remote health services**, the NHS will see 1.1 million GP hours a year freed up.

Qualcomm estimates that by 2035, 5G will support the production of up to £8.5 trillion worth of goods and services.

The truth is we don't know everything that 5G will deliver yet. Because it is set to be such a revolutionary technology, it is likely to be used to create services and applications we haven't even imagined yet.

How does it work?

First, the basics. When you ring someone, your voice is converted by your phone into an electrical signal that is transmitted to the closest cell tower via radio wave. It passes through a network of cell towers before the call arrives at the other person's phone. The same thing applies to other data such as photos and videos.

Wireless communications carry over the air via radio frequency – spectrum. 5G will use new, higher radio frequencies because they are less cluttered and they carry information much faster.

Although higher bands are faster they don't carry information as far so 5G will see a lot more, smaller multiple input and output (MIMO) antennaes to boost signals and capacity. Estimates suggest that this means 5G will support up to 1,000 more devices per metre than 4G.

Another change with 5G is that operators will be able to 'slice' a physical network into multiple virtual networks – they will be able to deliver the right slice of network depending on how it is being used, and therefore manage their networks better. For example, an autonomous car has different network requirements to a simple IoT device.

Will I need a new phone?

Yes, you'll need a 5G-capable phone to connect to 5G, and you'll be able to get one pretty soon. Chip-maker Qualcomm announced recently that its Snapdragon X50 5G is being implemented by a number of phone makers for mobile device launches starting in 2019.

What are the challenges?

Beyond the technological challenges of ensuring the technology works as expected, there are other hurdles too that 5G players will need to overcome.

- **Spectrum**

Spectrum availability is not limitless. The radio frequencies used for 3G and 4G are already crowded and as mentioned above, 5G will run on higher frequency bands to deliver the faster data speeds.

The spectrum for 5G needs to be allocated via an auction. This is set to take place soon. In addition, because of concerns about spectrum running out, the industry is challenged to come up with smarter ways to use what is available – for example, by making spectrum available on demand and only allocating the amount required for a particular task.

- **Making it pay**

Network operators have already spent billions on 4G networks and until they have developed it, they don't know what 5G will cost. They do know it will be expensive. If the telecommunications industry is to recoup its outlay on 5G, companies need to ensure the services will make them enough money.

Recent research from Ericsson found that consumers anticipate much faster speeds and better coverage from 5G. Thanks to the services 5G will enable, people will use a lot more data too. However, 13% expect their price plan to drop. Others won't be willing to pay any more than they do now. It's a dilemma for operators and even they admit they don't have all the answers yet.

Finding the financial balance will involve operators trying out new business models and pushing into new areas where they deliver services as well as connectivity. These potential sectors include connected factories, autonomous cars, digital health and more.

The future is 5G

While there is a lot of activity around 5G, not everything is set in stone yet. Standards are evolving, tests are ongoing, and phones are in the making. As 2020 gets closer you'll be hearing a lot more about 5G and how you can benefit from it. Watch this space.

https://www.lifewire.com/5g-fixed-wireless-fwa-4178934

Mobile 5G vs Fixed 5G

What's the difference between mobile 5G and fixed wireless access 5G?

Updated March 06, 2019

5G is available in two forms: as a mobile service (Mobile 5G) that you can access via your phone from anywhere with proper coverage, and as a fixed service (Fixed Wireless Access / FWA 5G) that works in one place only. There are benefits and disadvantages to each.

Mobile 5G

- Works when you leave home
- Could provide 5G internet to other devices on the go
- No hardware installation is necessary

FWA 5G

- All your devices get 5G, including computers
- Provides a reliable connection
- More likely to offer unlimited data usage

At the end of the day, a mobile network and a fixed wireless access (FWA) network do exactly the same thing: provide access to the internet. However, like we discussed already above, the difference is that one of them lets you reach the internet from your phone while you're out and about, while the other is only useful if you need internet at one place, like at home.

Not all ISPs offer the same kind of 5G access, so knowing how they differ is important when choosing which provider to go with. Of course before getting that far, deciding how you *want* to take advantage of 5G service is important: do you want 5G-powered Wi-Fi at home and/or are you just interested in super-fast mobile access?

Mobile 5G Pros and Cons

Advantages

- Access to the mobile network's entire coverage area
- Easy setup: Buy a mobile device and connect it to a provider with a 5G plan

Disadvantages

- It's easy to get charged overage fees for too much data usage
- You could experience poor coverage in some areas

Accessing a 5G network anywhere you go might be exactly what you're after. You could ultimately use your smartphone, tablet, smartwatch, etc, while you're in a car, outside the range of your home Wi-Fi, or anywhere else you can get a decent signal.

Relying on a mobile network to deliver 5G is great when it comes to mobility (obviously) but probably not so great for reliability or cost.

5G isn't much different from older mobile technologies like 4G when it comes to coverage reliability. You might get perfect service one place but spotty coverage, or total lack of coverage, a few minutes later when you move somewhere else.

On top of that, mobile 5G will most likely result in high phone bills or force carriers to offer ultra-large or even unlimited data plans. Of course, an unlimited data plan is nothing to complain about, but if you end up with a limited data plan, you might find that due to the speed at which you can access data, you'll consume a lot doing things like playing VR games, streaming videos, using AR apps, and browsing the web.

Fixed Wireless Access 5G Pros and Cons

Advantages

- Fast, 5G-based Wi-Fi access throughout your house
- A dedicated signal from a nearby 5G cell

Disadvantages

- Signal is lost the moment you leave
- Special hardware is required

Fixed wireless access has the major benefit over mobile 5G of reliability. When you're in one location, you're much more likely to receive constant coverage because there aren't as many moving parts that could interfere with the signal.

Another aspect of FWA that makes it outperform mobile access is when it comes to using multiple devices at once. When you're at home with 5G internet, every device in your house can communicate via Wi-Fi with the router to access the fast connection provided to the 5G modem from the closest 5G cell tower. Mobile 5G doesn't offer that same ability, at least not easily.

For example, if a family wants to run an Xbox, multiple laptops, several smartphones, some smart TVs, and other devices on a 5G network but all they have access to is a smartphone that can reach a mobile 5G network, then that device has to be converted into a hotspot to feed internet to the other devices. When the phone leaves the vicinity, all of those devices will lose access to the internet.

Compared to mobile 5G, a FWA 5G plan is also more likely to allow unlimited data usage. Most ISPs don't cap data usage for at-home connections like they do with some mobile connections. If multiple devices need access to the 5G network, you'd be way better off getting an unlimited at-home 5G service than a mobile one.

Another advantage over a mobile 5G plan is when accessing the internet indoors. Mobile coverage isn't always great indoors, even if you use a 5G hotspot with your mobile 5G connection. However, in a FWA setup, the 5G connection is really only between the modem and the tower, which is fine tuned during installation. The great coverage in the house is Wi-Fi, or even wired, just like you're probably used to.

However, with 5G fixed wireless access, you can't just buy a device and be done like you can when using a phone on a mobile network. Instead, a special modem and antenna must be installed either on the outside or inside of your house in order to receive 5G service from the nearest cell. Additionally, like with any home internet service, you'll also need a router, potentially a new one that can take full advantage of the fast connection.

Do You Have to Choose?

If you can't decide whether to get a 5G fixed wireless connection at home, one thing you can do is use a 5G mobile hotspot. A device like this connects to a mobile network like a phone does, but can also create it's own Wi-Fi network so that other devices in the vicinity can take advantage of the connection as well.

For example, with a 5G mobile hotspot, you could connect your gaming consoles, computers, tablets, phones, etc., to the 5G network you subscribe to but without having to set up a true FWA system at your house. Any wireless device in your home that's currently on Wi-Fi can connect to a hotspot.

That said, the disadvantages we mentioned above for mobile 5G apply to a hotspot, too. However, if you're lucky enough to get clear service inside your house and are on an unlimited plan, then going with a 5G hotspot is much like setting up your own 5G FWA system but without the installation hassle or extra hardware and antenna costs.

How to Get Mobile or FWA 5G

There currently aren't any live mobile 5G networks that everyday consumers can access, for more reasons than one, but partly because there are no 5G smartphones on the market just yet.

However, many mobile carriers are planning to release mobile 5G service this year, and some even started in 2018 with select customers and businesses. AT&T is one example where mobile 5G is available for a small number of people in select cities.

Verizon is currently the only company offering fixed wireless access 5G in the United States. It's called Verizon 5G Home and is limited right now to just a handful of locations.

See when 5G will roll out to the US for more information on the progress carriers are making to release both mobile 5G plans and FWA 5G plans. If you're not in the US, check out our 5G Availability Around the World piece.

Fixed Wireless Access

An economic study

ericsson.com/fwa

Key findings

Less than half of the world's 2.2 billion households will have a physical – copper, cable or fiber – broadband connection by 2023. In many markets, it is not economically viable to continue building out such fixed broadband infrastructure. The high population coverage of 3GPP cellular technologies, with their ever-increasing network speeds, creates an opportunity for fixed wireless access (FWA) deployments. Globally, these opportunities can be divided into three different segments: 'Connect the unconnected', 'Build with precision' and 'Wireless fiber'.

Successful FWA strategies are based on shared investments, leveraging mobile broadband (MBB) access and spectrum bands instead of dedicated FWA-only networks. This approach not only reduces risk – which is spread across FWA and MBB business – but also involves lower upfront investment and shorter time to market than fixed broadband deployments. For mobile-only operators, FWA is an adjacent growth opportunity, focused on selected market areas; typically suburban and rural. For converged operators, FWA is a complementary access technology which can address areas where it is not cost-effective to build out physical broadband infrastructure.

FWA capital investment can be targeted at selected areas in three steps. First, operators can utilize existing assets. Second, they can add additional capabilities such as spectrum bands and capacity expansions. Third, where needed, they can densify with additional sites.

The payback period for an FWA 'Build with precision' scenario could be as low as one year. Sensitivity analysis using ±50 percent variability in the main parameters shows payback of less than two years for 80 percent of the simulated cases. Average revenue per user (ARPU) and average data consumption are key variables influencing FWA profitability. Scalable investments aligned with demand and usage deliver a profitable FWA business, even in situations with very high traffic growth and lower uptake.

Successful implementation strategies for FWA should take into account the existing operator assets (whether mobile-only or converged) and the FWA topology sweet spot (whether for urban, suburban or rural areas) for the FWA segment being targeted.

Finally, FWA is a future-proof solution for delivering broadband to households, enabling operators to start with 4G and evolve to 5G according to segment needs.

Five key principles for FWA deployments

01 Profitable growth opportunity with large share of underserved households, not just in emerging markets

02 Shared investment with mobile broadband using same assets and spectrum bands, minimizing risk and having lower upfront investments than fixed broadband

03 Tailored solutions for different segments with dimensioning based on fixed and mobile paradigms

04 Surgical capex allocation per targeted area in three steps: Utilize, Add and Densify

05 Future proof broadband solution with evolution of LTE and 5G

Introduction

FWA is by no means new. The first FWA offerings were focused on voice services, based on 2G technology and known as wireless local loop. Later, a few operators addressed the household market for voice and Internet connectivity with 3G and dedicated FWA-only WiMAX technologies.

Given the limited success of these earlier offerings, is there now a real opportunity for FWA? Is it different this time? Is it possible to make a future-proof FWA offering? Yes, there is a positive answer to all these questions. The goal of this study is to answer these questions and to provide a detailed business case analysis for addressing the FWA opportunity profitably.

Figure 1: Drivers for FWA

There are many reasons FWA is an excellent opportunity for the industry.

First, on the demand side, there is a growing pull from households and small and medium-sized enterprises (SMEs) worldwide for connectivity and bandwidth. Globally, there are just over 2.2 billion households and, according to the ITU[2], there are about 970 million fixed broadband connections (~45 percent penetration). Even though this figure has been increasing at around nine percent annually over the past five years, there will still be around one billion households without a physical broadband connection in 2023.

In connected households, Internet usage keeps growing and video streaming has boosted demand for high-performance broadband globally. In many areas, this demand is not fully met with legacy xDSL or cable, driving the need for superior technologies. This is true even in developed economies. For instance, Verizon points to an FWA-addressable market of 30 million households in the USA (approximately 24 percent of households[3]).

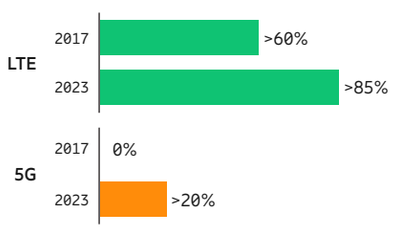
Given this demand and the proven link between increased broadband penetration and economic growth, governments in many countries are fueling connectivity and broadband roll-outs through various programs and subsidies, many of them agnostic to the type of technology used. Moreover, many operators are looking for additional revenue growth opportunities, where broadband services for households represents a large potential revenue pool.

On the supply side, there are important drivers that position FWA as a suitable technology to capture this market opportunity. Mobile technology enhancements such as carrier aggregation and advanced antenna systems are providing further improvements in mobile speeds and performance. What is more, new spectrum in several bands is being made available, in particular for capacity, including higher mid-bands (3–6 GHz) and high bands (such as those currently starting above 24 GHz).

As a result, the network cost per delivered bit keeps falling. As an example, a site fully evolved with 4G and 5G capacity will deliver mobile data ten times more cost-efficiently than a basic 4G site today[4].

In addition, FWA offers shorter time-to-market than fiber and cable. First, there is existing MBB coverage to be leveraged. By end of 2017, 4G population coverage was over 60 percent and is forecast to grow to more than 85 percent by 2023, when 5G population coverage is expected to exceed 20 percent. Second, deployment of new mobile sites typically involves less lead-time for permits compared with that for physical broadband infrastructure.

Figure 2: World population coverage by technology



[2] ICT Facts and Figures 2017, ITU

[3] Verizon to launch residential 5G services in up to 5 cities in 2018, Verizon 2017

[4] The 5G Consumer Business Case, Ericsson 2018

Segmented opportunity for FWA

The FWA opportunity of over one billion households looks different in different parts of the world. Each of these segments needs to be addressed according to their differing needs, mainly based around subscriber expectations, service aspects and ARPU levels (as described in the Ericsson FWA handbook[5]).

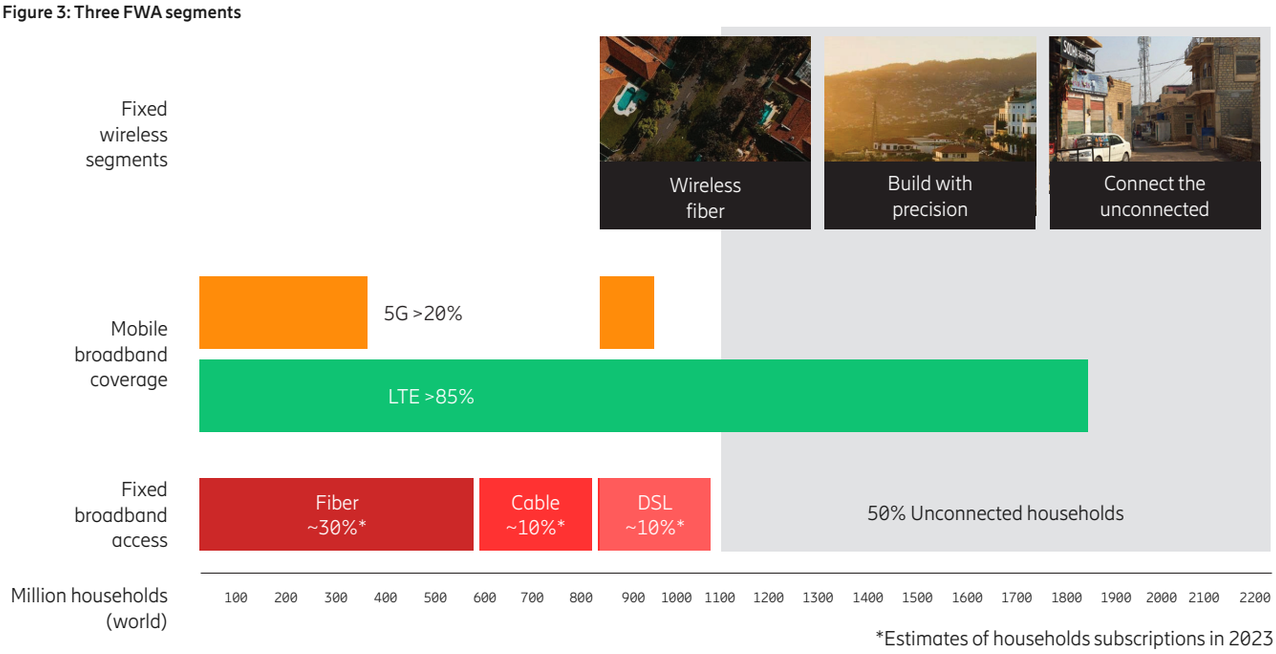
The first segment is 'Wireless fiber'. Here, there is competition with fixed broadband, driving a need for higher-rate offerings and capacity. The ambition is to provide fiber-like speeds and handle households' TV needs with a corresponding high ability to pay. Typical sold data rates are 100–1,000+ Mbps and ARPU levels of USD 50–100.

The second segment is 'Build with precision'. Here, there may be some availability of xDSL. However, there is a limited business case to provide fixed broadband alternatives. The need is for high data rates and capacity, along with a willingness to pay. Typical sold data rates are 50–200 Mbps and ARPU levels are around USD 20–60.

The third segment is 'Connect the unconnected'. This segment is characterized by virtually non-existent fixed broadband alternatives, and MBB using smartphones is the dominant way of accessing the Internet. ARPU levels are limited and user expectations of access speed are relatively low. Typical sold data rates are 10–100 Mbps and ARPU levels are around USD 10–20.

It is worth noting that for 'Connect the unconnected' and 'Build with precision' segments, we assume that linear TV needs are satisfied by other means, such as terrestrial or satellite TV. For the 'Wireless fiber' segment, some offerings are likely to include a full IP-TV offering, implying dramatically higher data consumption.

Figure 3: Three FWA segments



*Estimates of households subscriptions in 2023

[5] Fixed Wireless Access Handbook, Ericsson 2018

Financial analysis for 'Build with precision'

Assumptions

Market segment: 'Build with precision' implies precise targeting of a service area. The objective is to select areas with limited fixed competition, a good existing wireless network, willingness to pay and sufficient household density. These are typically sub-urban and rural areas.

Demographics and uptake: for this case, we set a population density of 500 households per square kilometer, with a potential of close to 450 households covered by one radio base station site. We assume a gradual customer uptake to reach 30 percent of the market in five years.

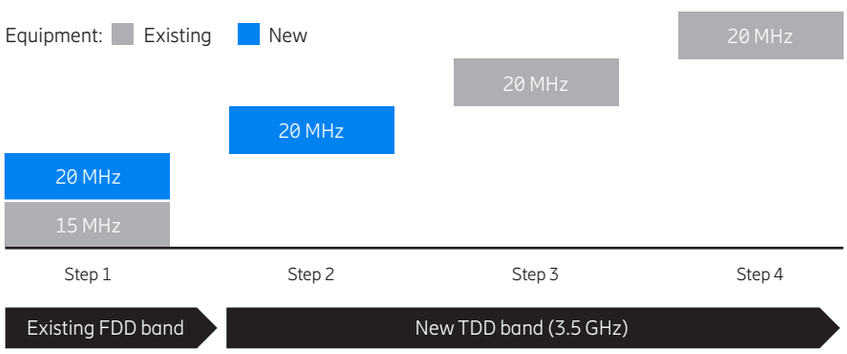
Challenges: customers already have experience of fixed broadband and most likely want a robust solution to cope with video on demand, putting pressure on FWA sold data rates and capacity. At the same time, traffic is expected to grow at 30 percent compound growth rate per year.

Offering: tiered offers with a 'basic' plan and 'plus' plan, differentiated on sold data rates. Both plans are for dedicated household Internet service with limitations against excessive use in the contract, similar to fixed broadband services.
Pricing includes a monthly fee (ARPU) and a start-up fee. These plans do not assume any government funding from national broadband plans, which could improve the business case even further.

Figure 4: Tiered offering plans

Basic	Plus
Sold data rates: 50 Mbps	Sold data rates: 80 Mbps
ARPU: USD 40/month	ARPU: USD 50/month
Indoor CPE	Outdoor CPE
Start-up fee: USD 60	Start-up fee: USD 100

Figure 5: FWA solution – Radio network expansion steps



Note: New equipment includes new Radio and site equipment. Expansion on existing equipment requires only remote SW upgrade.

Customer premises equipment (CPE): there are trade-offs on performance, cost and ease of installation between outdoor and indoor CPE, with some operators selecting a mix of both. The 'plus' plan is modeled with an outdoor CPE to maximize performance, being 2-3x more efficient than indoor CPE. The 'basic' plan is based on an indoor CPE for ease of installation and lower cost, with lower performance and higher use of radio network resources compared with outdoor.

Network dimensioning: dimensioning for radio access network (RAN) is based on consumption at the busy hour. This busy hour can be translated to an average monthly consumption per household estimated at 70 GB for the 'basic' plan and 150 GB for the 'plus' plan. The first-year consumption rates grow at a compound annual growth rate of 30 percent. A minimum data throughput level is set to guarantee quality of service at busy hour, even for the households at the cell edge.

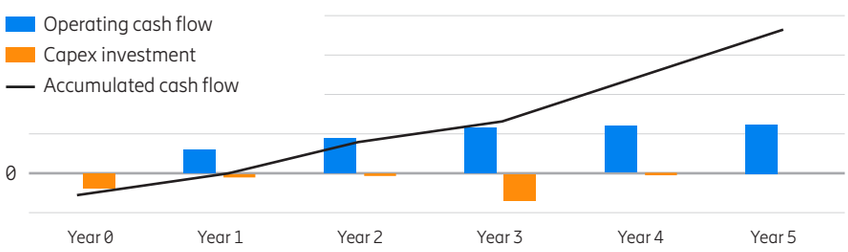
Solution approach: the first step is for the operator to utilize existing spectrum assets, starting with spare capacity, as existing utilization is typically below 40 percent of the site capacity. As demand picks up, new equipment is deployed to utilize acquired but undeployed 20 MHz LTE FDD spectrum. After that, new spectrum bands are aggregated together with new equipment. The next step is to move to mid-bands and add spectrum and radio such as 3.5 GHz (here we set TDD spectrum of 60 MHz). The mid-band spectrum is added in three software upgrade steps each of 20 MHz). Further detail on FWA evolution steps can be found in Ericsson's FWA handbook.

OPEX and CAPEX: in addition to the capital investments, network operating costs are included to cover incremental cost related to power consumption, backhaul transmission, and core and network support services. Customer acquisition costs and business operating costs are also taken into consideration. Spectrum costs are not allocated to this business case as these vary significantly per market.

Results

For the base case, payback is reached in around one year as shown in this chart. Even considering an annual average traffic growth of 30 percent per household, the network remains at step 2 at the end of the five-year period. The investment in mid-band (step 2 on 3.5 GHz) occurs at year three. Similar results are achieved for both 'basic' and 'plus' plans.

Figure 6: Cash flow (annual)



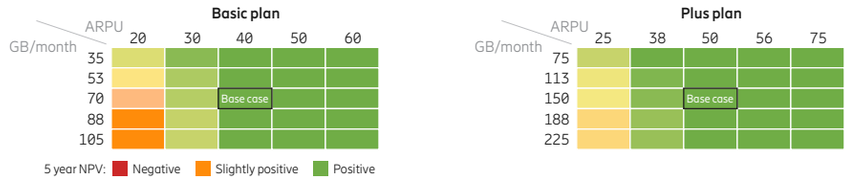
Sensitivity analysis

After testing many variables, we found that the four most sensitive variables for the FWA business case are market share, traffic growth per household, ARPU and traffic consumed per household (traffic at the busy hour per household). More than 600 simulations were performed for each of the offering plans above, varying all four variables simultaneously in a range of ±50 percent of the base case values. In more than 80 percent of the 600 simulations, the payback of the FWA business case was less than two years. At the same time, the network solution at step 4 was sufficient to address the capacity for 97 percent of the 600 simulations for the 'basic' plan and 93 percent of the 600 simulations for the 'plus' plan.

The charts below show a sensitivity analysis for ARPU and monthly average data usage with simulations of ±50 percent of both variables.

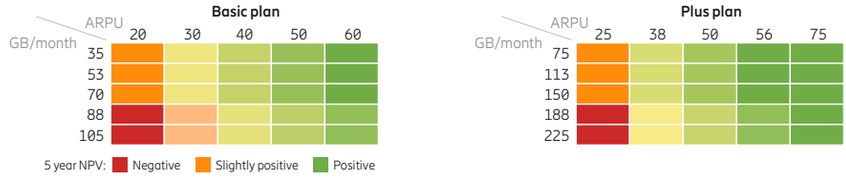
The green areas in all the cells of the matrix show a positive net present value (NPV) over five years (10 percent discount rate) for all the simulations.

ARPU and average monthly usage per household (± 50%)



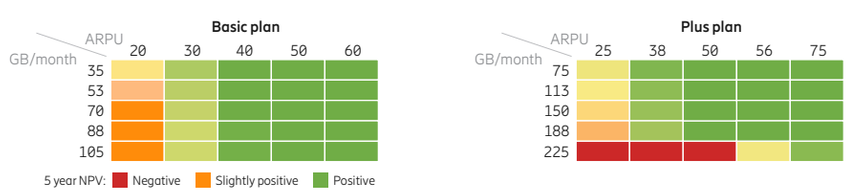
The FWA business case was tested even further in more extreme circumstances. For instance, the charts below show a sensitivity analysis in which the market share at year five is reduced from 30 percent to 15 percent of households. Even then, the NPV is positive in 23 of 25 simulations with equal results for both plans. These negative NPV values at low ARPU levels may also imply that an FWA approach for segment 'Connect the unconnected' could be more appropriate for these levels.

ARPU and average usage (± 50%) with 50% less customers



Traffic growth is another variable of interest. Sensitivity analysis of increasing the average traffic growth rate per household from 30 percent per year to 45 percent shows that all the simulations for the 'basic' plan offering would have a positive NPV after five years. For the 'plus' plan, three out of 25 combinations result in negative NPV. Looking closer at these negative cases, it is possible to see large average usage per household (on year one at 225 GB per month, growing to 1 TB at year five), implying that other solutions such as 'Wireless fiber' could be more appropriate for such high usage.

ARPU and average usage (± 50%) with household yearly traffic growth of 45%



Benchmarking against existing FWA offerings

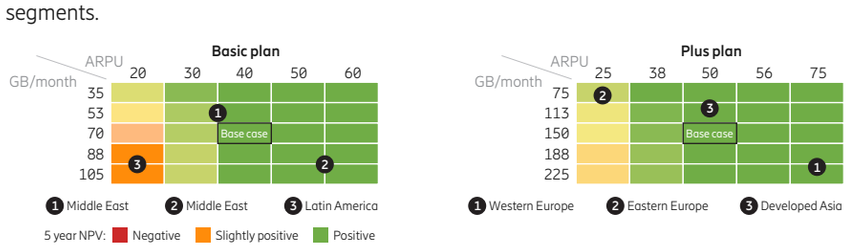
The sensitivity analysis shows that ARPU and average usage per household are key parameters in designing robust FWA offerings. Based on benchmarking from existing FWA offerings, it is possible to draw further conclusions around FWA commercialization.

The 'basic' plan is compared with three FWA plans for emerging markets based on indoor CPE.

One operator in the Middle East uses trade-offs of price and consumption to target FWA offerings to different segments. Some operators in Latin America find profitable FWA opportunities at USD 20 ARPU levels and large consumption at 100 GB per month – implying that such operators are successfully applying FWA alternatives for low ARPU segments.

For the 'plus' plan, there is a mix of emerging markets and developed markets using outdoor CPE for large consumption. All data plans line up in a diagonal, highlighting a linear relationship between ARPU and consumption. In these benchmarked cases all operators have a start-up fee, which ranges from USD 70 to USD 130.

Benchmarking FWA business case with FWA offers in the market



Business case implications for designing FWA strategies

Operator strategies for FWA should be designed according to local characteristics:

Market opportunity: households per location (population density), willingness to pay (GDP per capita) and usage (such as Internet browsing, video on demand, and gaming).

Competitive offerings: available technology in the selected location, such as xDSL, cable and fiber, and whether mobile operators have started to offer robust FWA solutions.

Operator assets: installed infrastructure, deployed (and under-utilized) spectrum, backhaul and other infrastructure.

Furthermore, the overall operator strategy plays a critical role:

Mobile-only operator: FWA as an incremental investment opportunity, targeting predominantly rural and suburban locations. Operators might consider complementary partnerships to address the go-to-market challenge (such as with broadcast, satellite or cable operators and OTT players). In addition, they should evaluate the time-to-market advantage of deploying an FWA solution compared with physical broadband infrastructure.

Converged operator: FWA as a complement to overall fixed broadband strategy. Operators should consider the most suitable technologies for each type of topology, terrain and service level. The trade-off between FWA and fixed broadband solutions should ultimately be made on the 'last mile', as this will contain most of the required assets, such as transmission and core networks to serve both mobile and fixed offerings.

Fixed or cable operator: FWA as a complement to overall fixed broadband strategy, considering FWA as wireless last mile for selected locations. Operators should consider a mobile virtual network operator (MVNO) arrangement or partnership with mobile-only operators.

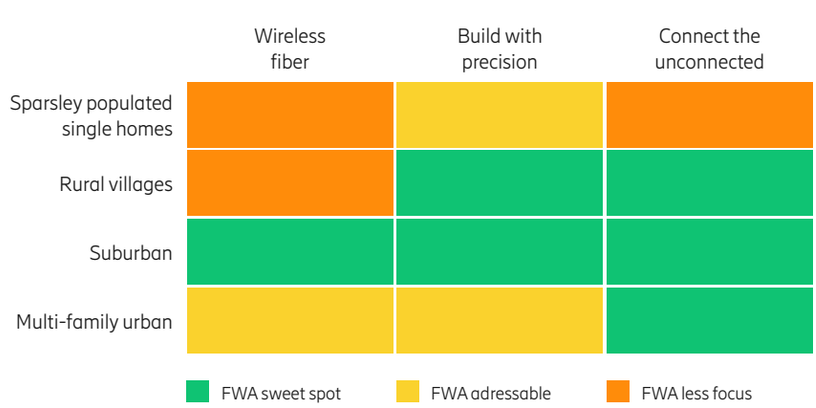
Sweet spot for FWA strategies

Taking into account the achievable ARPU, availability of fixed broadband alternatives, population density and cost of deployment to address these homes, the typical FWA sweet spot per segment can be summarized as shown in the illustration to the right.

The 'Wireless fiber' segment is characterized by fiber-like speeds and the ability to handle households' TV needs. The sweet spot here is typical suburban environments, where there is a good operator business. In sparsely populated areas and rural villages, a positive business case is much harder to achieve (without government subsidies) as the network costs are often rather high in relation to the total revenue potential.

The 'Build with precision' segment sweet spot lies in suburban or rural villages/towns that are underserved.

Figure 7: Sweet spot for FWA strategies



The 'Connect the unconnected' segment is characterized by virtually non-existent fixed broadband alternatives. Even though ARPU levels are limited, it has a sweet spot that stretches from urban environments to rural villages.

Technology choices for FWA

With the advent of 5G, technology choices are high on the operator agenda. On one hand, operators want to make technology-proof investments ready for 5G. On the other hand, they want to capture the FWA opportunity now, ahead of competition. At the same time, operators want to leverage today's mature, large and affordable 4G ecosystem, as well as existing spectrum assets.

FWA will not be driven by technology, but rather the market opportunity for each operator in a specific geography, as with traditional fixed broadband. From this starting point, operators should select the combination of technologies and the spectrum strategy most suited to the market opportunity.

When it comes to spectrum, a multiband strategy is vital to manage large volumes of data traffic. FWA offerings for 'Connect the unconnected' could be handled with partial or full deployment in existing 4G lower mid-bands (1–3 GHz). That approach could certainly serve as an entry level offering for 'Build with precision' for an operator with large spectrum assets.

As new higher mid-band spectrum becomes available (typically 3–6 GHz), it will enable even more capacity for 'Connect the unconnected' and 'Build with precision'. Even 'Wireless fiber' could then be delivered with combinations of mid-band spectrum assets.

New high-band spectrum, currently starting above 24 GHz (also referred to as millimeter wave), will add significant capacity. These high spectrum bands combined with lower bands would deliver enhanced capacity with improved coverage for more demanding scenarios, in particular for the 'Wireless fiber' segment.

FWA can be delivered by 4G and 5G technologies. 'Connect the unconnected' FWA offerings are more likely to be based on 4G, while 'Wireless fiber' offerings would benefit from high-capacity 5G from the start. At the same time, important technology features that provide large capacity gains, such as advanced antenna systems and beamforming, are available for 4G and 5G.

Finally, new technology features such as dynamic spectrum sharing will enable the radio access bearer to adjust between 4G and 5G instantaneously, based on the traffic being carried, in real time. As a result, operators that select 5G-ready equipment have the advantage of a smooth transition from 4G to 5G as traffic volumes continue to grow and ever more affordable CPE becomes available.

Figure 8: Technology choices for FWA

EN/LZT 20/28701-FGD 101 449

https://5g.co.uk/guides/what-is-5g-fixed-wireless-access-fwa/

5G Fixed Wireless Access (FWA) technology | What Is It?

By Jon Mundy

Updated: 24th September, 2018

5G Fixed Wireless Access (FWA) technology | What Is It?

Fixed Wireless Access, or FWA, is an established means of providing internet access to homes using wireless mobile network technology rather than fixed lines.

More than 1 billion homes worldwide still find themselves without a regular broadband connection. Fixed Wireless Access, or FWA, is an established means of providing internet access to homes using wireless mobile network technology rather than fixed lines.

While FWA can often prove more convenient to set up, its key weakness compared to fixed line broadband is performance. Current mobile network technology simply isn't able to provide download speeds or latency levels that can compete with a modern fibre broadband connection.

However, the next stage of FWA will utilise 5G network technology, such as beam-forming and a high-frequency mmWave (millimeter wave) spectrum, to provide a considerable performance boost to wireless broadband services.

According to an April 2018 Market Insights report, the 5G FWA market is expected to grow 84% between 2019 and 2025. It could eventually be worth more than $40 Billion.

Why is 5G FWA such a big deal?

5G FWA retains the key benefit of current FWA offerings in that it enables the establishment of a quick and cheap broadband service, even in areas that don't have ready access to fixed line home broadband. 5G FWA doesn't require any engineering works at the customer end - just the provision of so-called Customer Premise Equipment (CPEs), which can be readily self-installed by the subscriber.

The aforementioned Market Insights report estimates that 5G FWA will reduce the initial cost of establishing 'last-mile' connectivity by as much as 40% compared to a physical fibre line approach.

As a result, 5G FWA is expected to have a huge impact even in developed markets like the US, where there is a sizeable disparity in broadband accessibility between the major cities and sparsely populated rural areas.

The chief advantage here, however, is performance. 5G Fixed Wireless Access will be able to deliver a level of service that's similar to a fibre-based broadband network, and should even be able to provide data speeds that are well ahead of current broadband standards.

Initial 5G trials reported download speeds of 10 to 25Gbps, while the current average UK home broadband speed is around 30Mbps. While so-called 'gigabit-speed' home broadband services are incoming, 5G FWA could prove to be a match in many instances.

More recently, in July 2018, the University of Sussex collaborated with Plum to conduct a practical 5G test with clear ramifications for FWA. These tests operated in the recently auctioned 3.5GHz band, and modelled the complicated ways in which 5G signals will interact with buildings and trees. Despite these conditions, the test recorded data speeds that were as much as 100 times faster than normal broadband.

Naturally fixed broadband standards will continue to improve as well, but that's not the point. What this means is that 5G FWA needn't just be a replacement service in areas where fixed broadband is unavailable. It could also be offered as a competing service to fixed home broadband, even in more built-up and highly populated areas. More competition, of course, means lower prices and improved services for the end customer.

Why is 5G FWA so much better than 4G FWA?

5G FWA will be able to utilise much higher frequency bands than current 4G networks can support. This will include so-called millimetre bands like 28GHz, which have much more available spectrum than LTE.

This additional spectrum means that there will be more capacity for data traffic and greater download speeds.

These millimetre bands also have a tighter radio beam, so they can be focused for use by fewer users in the immediate vicinity. This means that performance won't be adversely affected by a high concentration of users, as is the case with current solutions.

Also important is the matter of of latency. With 5G latency predicted to be as low as 1ms, there won't be the significant lag in response times that 4G FWA suffers from. Just like with fixed broadband, when you click on a web link or hit play to stream a video it will respond immediately.

How will 5G FWA benefit 5G mobile?

5G FWA will support future mobile usage, and will operate to the same standards as forthcoming 5G mobile networks. The latter won't commence rolling out to the public until 2020.

This presents mobile operators with the opportunity to use 5G FWA as a means to prepare their networks for full-scale 5G network deployments.

In other words, 5G FWA can be used as a stepping stone to full 5G mobility. It could potentially contribute to a much smoother and quicker transition from 4G to 5G for mobile users.

Conversely, of course, future 5G FWA services will be able to make use of 5G network technology as it spreads around the country.

Who's working on it?

Since early 2017, the UK Government's 5G Testbeds and Trials Programme has provided impetus and funding to a number of University-linked 5G testbed facilities across the country. Fixed Wireless Access has been identified as a key 5G rollout model to emerge from these tests.

The 5G Testbeds and Trials Programme is closely related and shares a funding allocation with the Local Full Fibre Networks Programme (LFFNP). Fixed Wireless Access is cited as a "common interest" between the two, and the UK Government is encouraging close collaboration.

In the commercial space, Samsung is working on 5G FWA technology in a number of countries, including here in the UK. From July to December 2017, the Korean tech giant partnered up with British telecoms infrastructure firm Arqiva to conduct Europe's first UK 5G FWA trial.

Operating across several locations in central London, the test operated in the key 28 GHz band and yielded a stable two-way mmWave link with downlink speeds of around 1Gb. This would be sufficient to stream more than 25 UHD 4K TV channels simultaneously.

Arqiva has also started installing thousands of 5G access units on street furniture (such as lamp posts) across a number of London boroughs. This small cell technology will be used by 5G FWA services to wirelessly connect to receivers placed inside homes and business properties.

What about UK mobile network operators?

So far the UK's four major mobile networks have kept their 5G FWA cards close to their chests. However, now that the long-delayed 5G auction has taken place, we can expect more announcements to be made over the next year or so.

An August 2018 report carried out by IHS Markit quizzed a range of mobile operators across the globe on their 5G plans. Respondents of the survey widely expected fixed-wireless access (FWA) to be ready to launch before anything else.

One notable move in the UK FWA space came about in May 2017, when UK operator Three acquired UK Broadband, giving it a potential entry point into the mobile broadband market through the Relish brand.

We can also expect EE to be a major player in 5G FWA, especially now that it's owned by broadband giant BT. The company is expected to supply the first 5G network in the UK before the end of 2019.

Whether FWA will form a part of that early launch we're not yet sure. However, EE has been one of the biggest drivers of 4G-powered home broadband since 2013, and in February 2018 it rolled out a Fixed Wireless Access service to help reach the 580,000 UK homes that still don't have adequate fixed line access.

Away from the major mobile networks, in September 2018, UKWISPA (the official trade body representing the Fixed Wireless Internet Access industry) announced the broadband industry's first Quality Accreditation Programme for service providers. FWA is clearly about to get a lot bigger, and UK broadband customers are set to benefit more than most.

Useful read: What is 5G?

Three and Huawei demonstrate superfast 5G home broadband

21 November 2018

Three and Huawei took to the 2018 Huawei Mobile Broadband Forum in London to demonstrate one of the major ways we're likely to use 5G – home broadband, demonstrating its potential using Huawei's latest home broadband routers, which are the first 5G commercial terminals in the world.

While there's no information on how high speed the demonstration was, the companies are expecting final 5G home broadband services to deliver maximum download speeds of 2Gbps, with an average of 1Gbps for a single user. That's not just far faster than 4G speeds, but also far faster than most fibre broadband.

Indeed, recently Three commissioned a report that found that average current broadband speeds in the UK are just 46.2Mbps, though the same report suggested that 5G home broadband might initially be 80-100Mbps. That's still very fast, but some distance short of these latest estimates, so don't expect to be getting 1Gbps speeds on day one.

Take games and video to the next level

Three's demonstration with Huawei used Three's 100MHz C-Band spectrum and allowed attendees to experience things like cloud gaming and 4K video streaming.

Those are things that fast home broadband is capable of already, but that 4G would struggle with and that 5G should make even faster and smoother, not to mention opening up the possibility of even more demanding media applications, like streamed 8K video.

It's no surprise that Three was involved in this test, as the company has already said it plans to launch a 5G home broadband service in the second half of 2019 and has previously noted that 5G broadband won't just be faster than fibre in most cases, but that it could also be cheaper (both to roll out and for customers).

Of course, home broadband is just one application of 5G, and Three and Huawei will apparently work together on other 5G service tests across the UK, with a focus on train stations and other densely populated areas. Expect to hear news on those trials soon, as a full commercial launch isn't far off – Three, EE and BT have all said they're launching in some form in 2019, and EE has even announced which cities will be first to get its 5G service.

https://www.techradar.com/news/the-week-that-uk-5g-transformed-from-hype-into-reality

The week that UK 5G transformed from hype into reality

By Steve McCaskill November 16, 2018 Networking

UK operators detail more about 5G launches in 2019.

Back in 2015, the director of a British 5G research centre declared "5G will be the first generation of reliable connectivity to the extent we won't have anything called 6G."

Ignoring the fact that one project in Northern Finland has already started work on 6G networks, the quote encapsulates the nature of the 5G hypetrain.

Its supporters have promised not just the faster speeds and greater capacity to be expected of every major iteration of mobile technology, but revolutionary applications and an era of ubiquitous connectivity that will change the world forever.

"It's been a pissing content," observed Paul Hjul, the director of Crystal Web at the recent Broadband World Forum. "Hype is a good thing, but it can make you look like you're more innovative than you actually are."

RECOMMENDED VIDEOS FOR YOU...
CLOSE

EE 5G launch

But in the past week, a vision of what 5G will actually look like in the UK has emerged. All four major operators are working on 5G networks and applications, but EE and Three have finally offered some detail and a vague 2019 launch date.

EE has repeatedly stated its desire to be the first to launch a 5G network in the UK and has said it will upgrade 1,500 sites in 16 major cities during the first year of operation. The

launch is expected to coincide with the availability of the first compatible handsets and EE will also offer Fixed Wireless Access (FWA) broadband.

EE's early vision will be one of superior mobile broadband and converged networks comprising 5G, fibre and Wi-Fi, with more transformative elements waiting until the arrival of future standards that lower latency.

"5G in 2019 will not be about autonomous cars, and automated factories," said EE CEO Marc Allera. "5G in 2019 will be about delivering the best mobile experience you've ever had and getting the best speeds and connections."

Three investment

While EE was the first to launch 4G in the UK 2012, Three was the last, waiting until 2013. This strategy will not be replicated with 5G, with the company believing its 3.4GHz spectrum holdings mean it can lead the UK market for the first time.

Its £2 billion 5G investment programme includes new equipment, spectrum, IT upgrades and the creation of a new virtual core network. It is also targeting a 2019 release date, most likely in the second half of 2019.

It also believes there will be significant performance enhancements for mobile broadband users, but it is calling 5G 'wireless fibre' and emphasising its viability as a genuine alternative to fixed broadband.

"5G is another game-changer," declared Three CEO Dave Dyson. "It opens up new possibilities in home broadband and industrial applications, as well as being able to support the rapid growth in mobile data usage.

"We have been planning our approach to 5G for many years and we are well positioned to lead on this next generation of technology."

Overhyped?

Vodafone has previously detailed its plans to hold 5G trials in seven major UK cities before gearing up for a commercial launch in 2019. It too will offer enhanced mobile broadband and FWA and plans to have 1,000 5G sites by 2020.

Meanwhile, O2 is holding trials of 5G in parts of the UK (including the O2 arena) and has released a study into the potential economic impact of the technology on the country. However, it is the only major operator yet to offer a major insight into its rollout plans.

There are still a lot of variables. Operators continually complain about red tape preventing network construction, while there is need for more spectrum on multiple bands available at affordable prices.

But this was the week that 5G transitioned from an idea into a reality. Whereas the UK was the 54th country in the world to have a 4G network, it will be among one of the first to receive a 5G service – most likely from all four major operators.

In the early days, 5G will be for early adopters and 4G networks will continue to satisfy the demands of most users. This gives operators time to upgrade their infrastructure, expand coverage and identify the applications that will drive uptake and live up to the hype that has been generated over the past few years. Whatever that will be is anyone's guess.

"Because [the industry] got the killer app for 3G and 4G wrong, we're not even trying to predict this time round," quipped Adrian Scrase, CTO at ETSI.

However, Ofcom CTO Mansoor Hanif believes the killer app of 5G isn't an app at all.

"I think 5G is a killer platform that can handle services," he said. "3G was overhyped but 4G was underhyped as it was much better than we thought and 5G started with the wrong type of hype. We've moved to the right type of hype and I feel as though the platform is the areas that should be hyped. It's a battering ram to introduce other things like automation."

SAMSUNG

Who & How: Making 5G NR Standards

Understanding Key Features of 5G NR Standards and Samsung's Contribution

Understanding 5G Standards

Why is it necessary to have global standards?

When travelling abroad, we often find ourselves encountering many problems related to mobile devices like having to look for a particular power converter because of the differently shaped power outlet. Running out of power for your phone in a strange city might be something you have to deal with if you accidentally forget and leave your charger at the hotel. The chances are that the only ones available are incompatible with your phone. These problems exist because countries and manufacturers create and install products based on their own specifications or standards.

Imagine there is an international standard that unites all of these power outlets and chargers so that more electronic appliances are able to operate interchangeably. It will trigger greater competition that would lead to technical advancements. It will also help manufacturers to develop and produce products that target the entire world, rather than a handful of countries or buyers.

Previously, the mobile telecommunications industry had divisions of standards that differed by country, manufacturer and standard organization. Among these, only the strongest in the market, or in this case the most popular standards, emerged as the de-facto standards. Today these divisions are merged into global standards by international organizations – and have become the norm.

For the mobile industry, international standards are the main pillars of mobile telecommunications as using different standards for smartphones and base stations would mean that any form of communication like voice call or Internet access are made unavailable. Thanks to the establishment of global telecommunication standards, we no longer need to rent cell phones or purchase prepaid phones when travelling abroad. We can use our phones wherever and whenever we like via what we call 'global roaming'.

The impact that global standards has on the industry is vast. Not only are manufacturers able to mass produce, R&D costs are saved through preventing investment overlaps. Technologies are shared and democratized. This prompts greater competition among manufacturers to produce high quality equipment that are also affordable.

What does the 'G' in 5G stand for?

Mobile communication technologies were labeled 1G, 2G, 3G and 4G as it advanced, the 'G' here an abbreviation of 'generation'. While 1G is an analog communication technology that made voice communication services possible, 2G is a digital-based technology that introduced voice and text services. It is also responsible for incorporating camera features into phones. Web browsing, email, video downloading, picture sharing and other smartphone technology were introduced in 3G, 4G technology ushered in the era of Internet data services on smartphones.

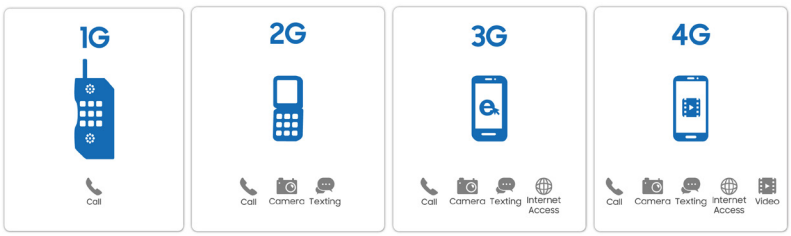


Figure 1 : Evolution of mobile communications technology

Each phase brings new and exciting capabilities and services to the end user. Progressing through to the next phase of mobile technology involves new frequencies and radio access technologies. New network technologies are also introduced so as to provide faster connection speeds and new infrastructure for innovative businesses as well as unprecedented services.

Smartphones as a 'service' was already introduced in the 3G era. However, as the use of smartphones became widespread, it became clear that 3G-based solutions are nowhere near enough to handle the ever-growing data traffic. Service providers realized that what they need is a new technology that has wide bandwidth availability in new frequencies. It was this particular need that drove wireless service providers to increase network capacity via 4G.

It was the international standards organization 3GPP (3rd Generation Partnership Project), a standards group that supports new technologies for the next generation, and developed the global standards for 4G LTE (Long Term Evolution). Each new generation offers significant "revolutions" in performance and capabilities compared to its predecessor. New generation, therefore, can be interpreted as new standards.

So, *who* makes the standards?

The International Telecommunication Union (ITU) sets the main visions and goals while 3GPP develops the standards. In the early 2010s when 4G LTE was close to finally being deployed, market experts made a forecast that data traffic will grow astronomically by 2020. This was a huge concern for the entire industry as it meant that the existing technology may be incapable of handling such data traffic. Discussions and preparations for next generation technology began. Industry leaders including mobile operators, manufacturers, organizations and institutions began research and development. **ITU, a specialized agency under the United Nations (UN), also started discussing technologies and technical visions for 'IMT-2020', which was announced in September 2015.**

'IMT-2020' was coined by ITU to define the technical specifications associated with 5G. ITU provides guidance for 5G developments to drive unprecedented next generation services and improved technical definition from 4G, also referred to as 'IMT-Advanced'.

Global standards organizations such as manufacturers, mobile service providers, research institutions, and international agencies develop standards based on the criteria set by ITU, which becomes approved after numerous debates. **Contrary to before when there were several global standards organizations, today, 3GPP is the largest standards body and is in charge of coordinating manufactures and organizations to develop 5G standards.**

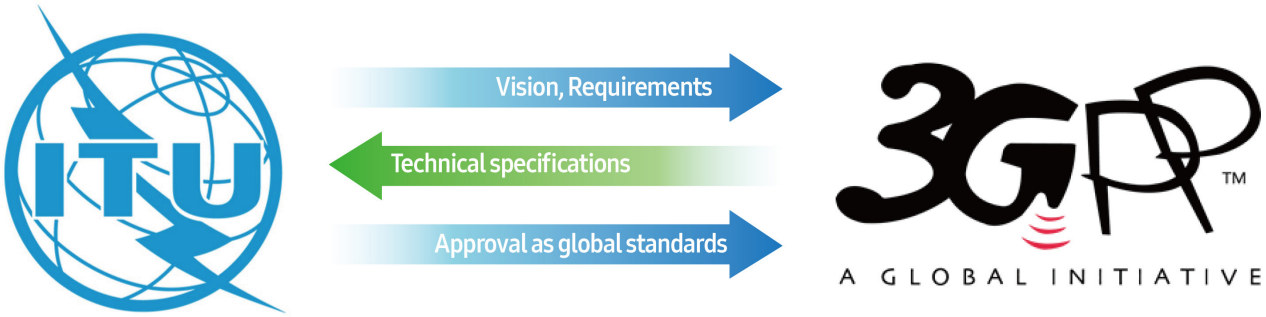


Figure 2 : Relationship between ITU and 3GPP

3GPP consists of around 500 entities including manufacturers, device producers, chip makers, mobile service providers, and international research institutions. It has developed WCDMA, HSPA, LTE, LTE-Advanced and many other international telecommunication standards throughout the evolution of mobile communication technology.

3GPP is currently the most influential organization in which global telecommunication leaders are members of. The organization sets deadlines and produces finalized results accordingly, supporting timely advances in technology and its commercialization. 3GPP has Radio Access Network (RAN) group to develop wireless access technology, Service and Systems Aspects (SA) group for service and system architecture, and Core Network and Terminals (CT) group for core network and devices. Each group has smaller Working Groups (WG) for practical level development.

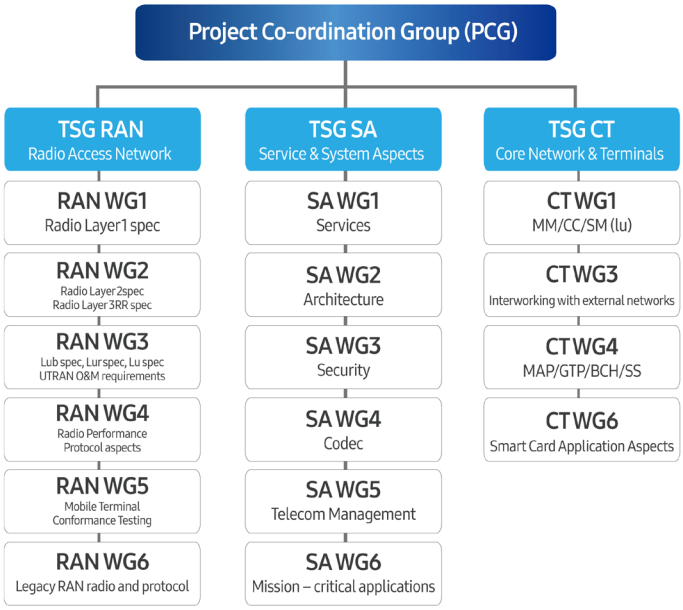


Figure 3 : Organizational structure of 3GPP

How is 5G standards different from the previous standards?

The three main technical aims of 5G are:

1. Enhanced Mobile Broadband (eMBB)
2. Ultra Reliable and Low Latency Communications (URLLC)
3. Massive Machine-Type Communications (mMTC)

ITU has classified 5G mobile network services into these three categories and has also outlined the different types of services each can offer.

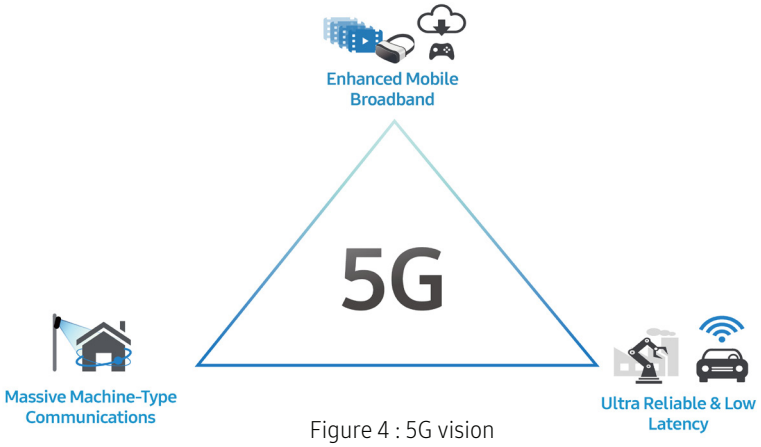


Figure 4 : 5G vision

1. Enhanced Mobile Broadband (eMBB)

eMBB aims to provide exceptionally fast data speeds, anywhere from 100Mbps up to 20Gbps per user, to focus on services that have high requirements for bandwidth and antennas such as high definition (HD) videos, virtual reality (VR), and augmented reality (AR). For instance, downloading a 15GB (Giga Byte) High Definition movie will take 240 seconds via 4G at the speed 500Mbps. With 5G however, at 20Gbps, the same movie will only take 6 seconds to download. The goal of eMBB is not to provide faster transmission speed only when you are near a telecommunication base station, but to serve at least 100Mbps data speed where the signal is weak (cell edge). Users in crowded areas such as airports and sports stadiums will be able to enjoy seamless HD streaming services.

2. Ultra Reliable and Low Latency Communications (URLLC)

The goal of URLLC is to provide real-time services that require extremely low latency and prompt responses like remote robot control, connected autonomous vehicles and interactive gaming. The delay time which used to be tens of millisecond (1ms = 1/1,000 second) in 4G will be reduced down to one millisecond in 5G via wireless resource management and network architecture optimization. On 4G, a connected autonomous vehicle traveling at 100km/hr will receive an emergency brake order with a delay time of 50 milliseconds(ms) - meaning the vehicle will stop after traveling 1.4m. With 5G however, the delay time will only be 1ms, and the vehicle will stop after traveling 0.028m. (Please note that the example does not represent the stopping distance per-se. Rather, it indicates 'by when' a vehicle will start 'applying' the brakes.)

3. Massive Machine-Type Communications (mMTC)

The goal of mMTC is to create an environment where a million homes and industrial IoT devices within 1 km^2 can be connected. mMTC aims to meet the demands of a highly developed digital society and focuses on services that include high requirements for connection density, such as smart city and smart agriculture.

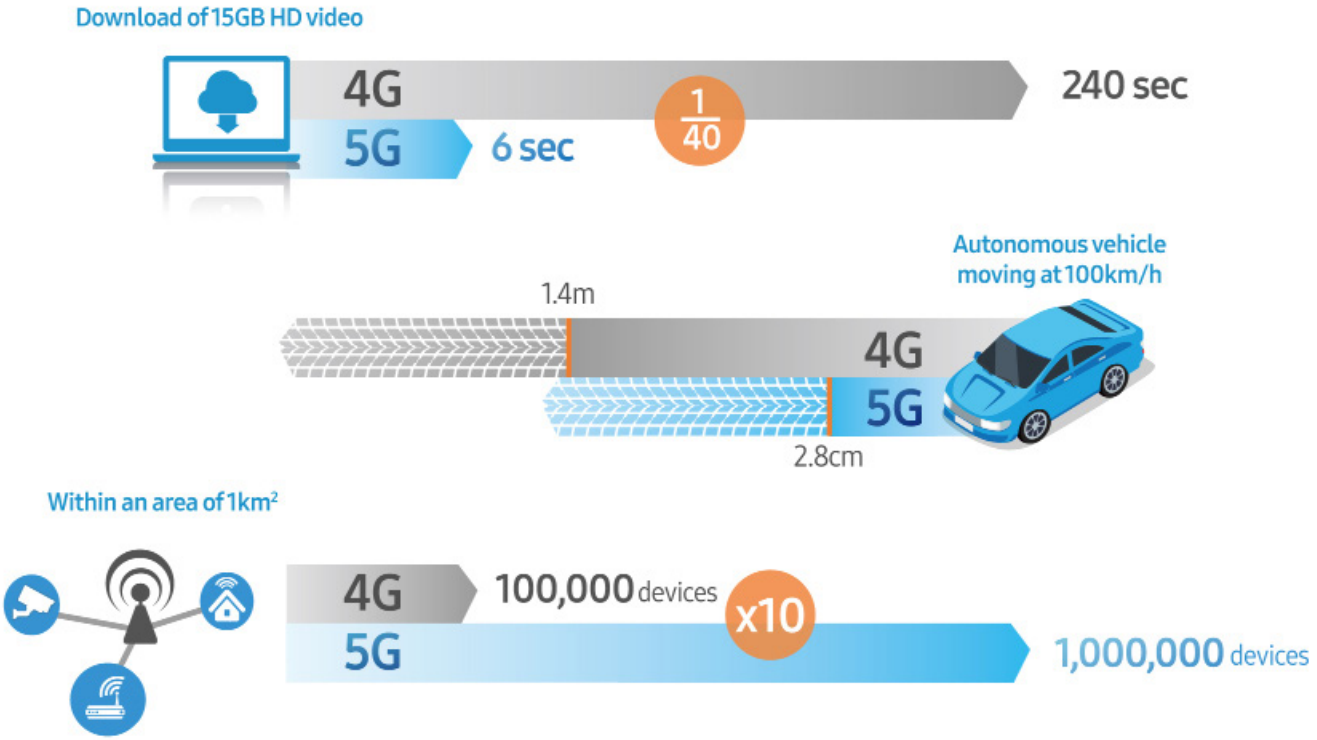
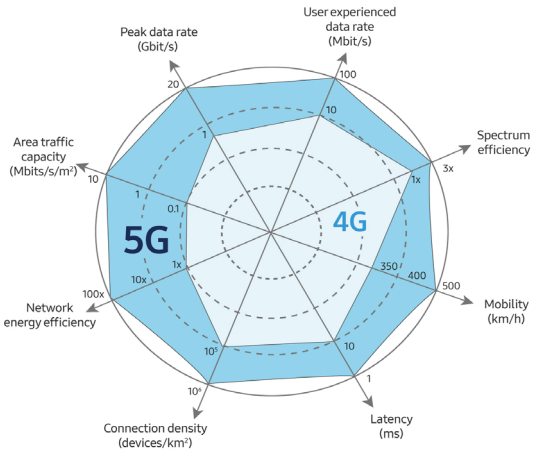


Figure 5 : Performance comparison example between 4G and 5G

The guides set by ITU is summarized in the below table. The comparison between 4G and 5G technologies is outlined in the figure below.



Item	4G	5G
Peak data rate	1Gbps	20Gbps
User experienced data rate	10Mbps	100Mbps
Spectrum efficiency	-	x 3
Area traffic capacity	0.1Mbps/m²	10Mbps/m²
Latency	10ms	1ms
Connection density	100,000/km²	1,000,000/km²
Network energy efficiency	-	x100
Mobility	350km/h	500km/h

Figure 6 : Comparison between 4G and 5G

When 4G LTE was first introduced, its peak throughput (or maximum speed) was 75Mbps which is less than one-tenth of what the industry had set as the highest peak throughput for the technology (1Gbps). It is only after the recent introduction of a 1Gbps-supporting device chip—expected to become commercialized in 2018—that 4G LTE was able to achieve this speed. Each generation of mobile communication technology takes several years since its launch to achieve the desired peak throughput. Similarly, 5G will start its services with a peak throughput of only a few Gbps, which will gradually increase to 20Gbps as targeted.

A wide range of frequency bands are required for 5G standards to provide high speed data transmission. **Accordingly, standards bodies are considering using both below and above 6GHz (ultra-high frequency bands like 28GHz and 39GHz).** Unlicensed bands are also considered as an option. While each country has its own rules and allocation policies, the chances are that most of them will assign bands ranging from a few hundred MHz to 1GHz to operators.

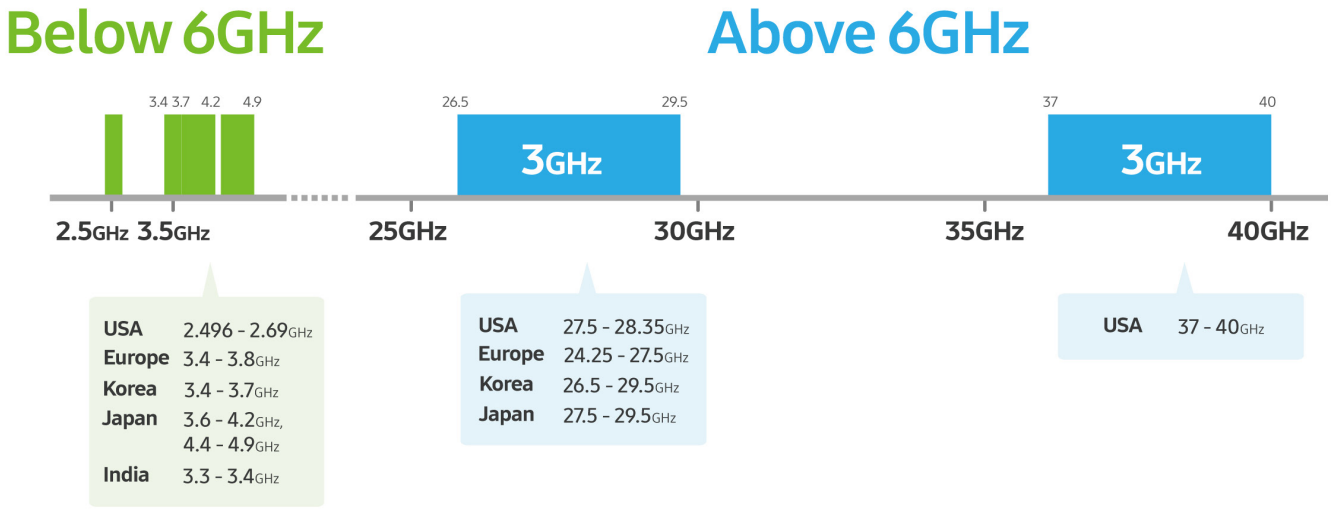


Figure 7 : 5G frequency bands

Make the Most Out of mmWave Frequencies: Beamforming

It might be relatively easy to secure high frequency bands because they have been avoided for their distinct disadvantages such as small coverage and low penetration rate. Beamforming technology has been introduced as a measure to overcome these weaknesses.

Beamforming technology controls multiple antennas so that strong concentrated signals are transmitted in one particular direction, while making sure that unnecessary signals do not go in different directions. The technology enables mmWave frequencies to travel far with less interference from other signals. The more the antenna elements, the sharper the beam shape. This also means that more energy is concentrated. However, the directionality of millimeter-wave (mmWave) communications creates a significant challenge in serving fast-moving mobile terminals and it is necessary to keep track of the sharp beam continuously.

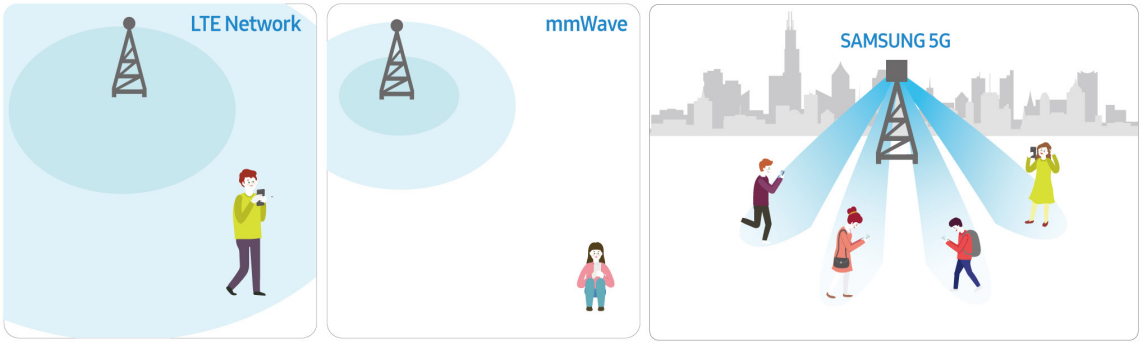


Figure 8 : How beamforming technology works

Improve Spectral Efficiency: Massive MIMO

Massive MIMO (Multi-Input Multi-Output) technology controls the antenna array of many antenna elements to generate multiple beams simultaneously, and each beam carries a different signal to the user. Spectrum efficiency is enhanced as it allows multiple users to use the same wireless resource simultaneously. A similar MIMO technology is currently being used with 4G. However, the beams are not sharp enough to identify each user, making MIMO a lot less efficient than it will be in the 5G era. MIMO in 4G uses one-dimensional antenna arrays arrangement that limits the freedom of antennas, meaning it can distinguish users in horizontal direction only. In contrast to this, MIMO in 5G supports more users simultaneously by incorporating a two-dimensional antenna array to cover both horizontal and vertical directions.

How massive MIMO technology works

Make 5G Services Easy & Flexible : Network Slicing

The aim of 5G standards includes distinguishing services via network slicing and quality-of-service (QoS) assurance features. On 4G, data services such as video streaming, Internet surfing and navigation are provided through a single pipeline or mobile resource. This makes it impossible for carriers to distinguish different data services. This also means that QoS cannot be guaranteed for each service.

During the 5G era, network slicing will allow carriers to create virtual data pipelines for each data service. This means that QoS will be assured for every service. Network slicing will also ensure the quality of data transmission for time-sensitive, mission-critical services such as connected cars. Ultimately, the technology allows carriers to develop unprecedented business models.

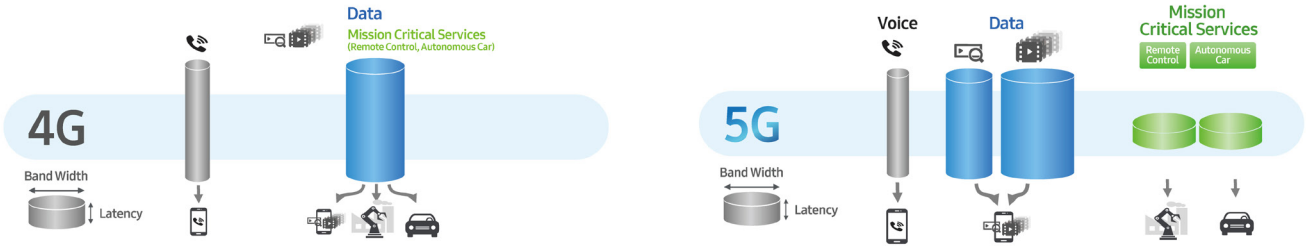


Figure 10 : How network slicing technology works

What are NSA and SA standards?

3GPP has taken a phased approach and introduced NSA (Non-Standalone) and SA (Standalone) architectures for 5G evolution. While the SA architecture ensures that both control and data channels utilize 5G networks, NSA would leverage the existing LTE radio and core network as an anchor for coverage. The user plane or data plane, which corresponds with data traffic, will be managed via 5G network. The initial 5G deployments are likely to be based on 5G-NSA architecture.

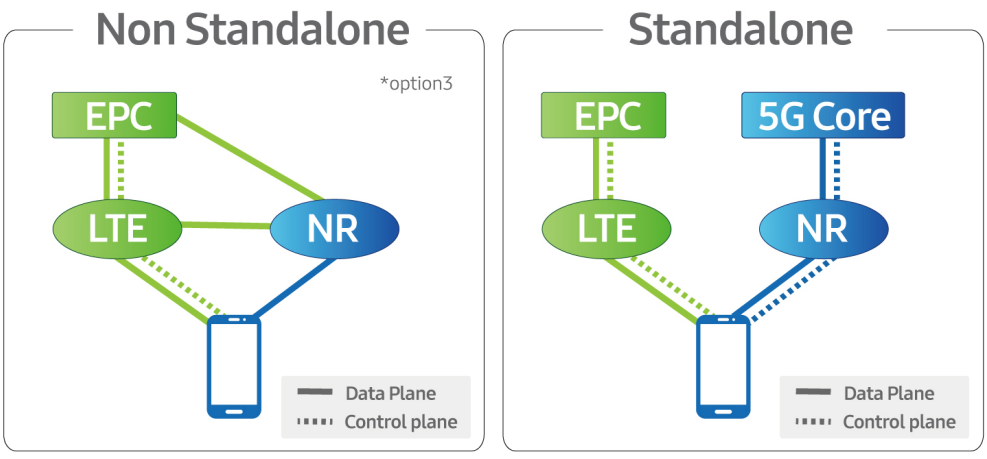


Figure 11 : How NSA and SA work

When is 5G Standards released? & What does the 'release' exactly mean?

Global telecommunication standards take a long period of time to complete a series of discussions. Even after next generation technology is released, previous generation technology standards are continuously updated and improved. The below figure shows 3GPP's standards release schedule. 3GPP announces different specifications over time and numbers them accordingly. For instance, while Release-14 or Rel-14 focuses on 4G LTE upgrades, Release-15 is dedicated to building the world's first global 5G standards - which will be announced in June 2018.

The areas covered by each release can overlap. For example, LTE enhancements from Rel-14 will be included in Rel-15. As can be seen in the diagram below, 3GPP is planning to split the 5G work into two phases. Phase 1 (Rel-15) will look at the requirements that are important for the commercial needs of the day. Phase 2 (Rel-16) will look at more features, use cases and detailed requirements.

Back in December 2017, 3GPP announced that Release-15's 5G New Radio standards is dedicated to NSA architecture in which LTE system serves as the signaling anchor. The 5G NSA architecture is a technology only for a transitional phase where 5G mobile technology and 4G core networks co-exist. It will not be commercially launched until 5G SA architecture, a complete 5G infrastructure, is deployed. SA architecture will be announced in June 2018.

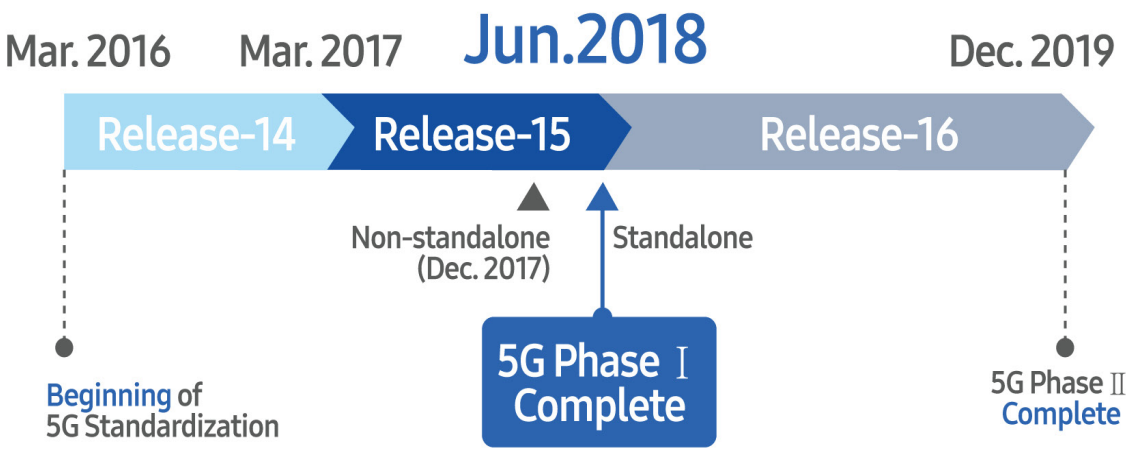


Figure 12 : 3GPP standardization timeline

Insights from 5G Standards Experts

In-depth interviews with experts, currently serving as 3GPP standards chair and vice chair persons on behalf of Samsung Electronics

Samsung Electronics actively participates in the development of 5G standards by serving as chair and vice chair for various working groups within 3GPP

ERIK GUTTMAN /Samsung Research United Kingdom (3GPP SA, CHAIR)

Q1 / Could you start off by explaining what the role of 3GPP is?

The 3rd Generation Partnership Project (3GPP) develops, enhances and maintains telecommunications standards. It works on behalf of standards organizations based in several geographies: North America, Europe, China, Korea, Japan and India. It is through these Standards Development Organizations (SDOs) that the standards that complete the process in 3GPP are transcribed and published formally.

Further, there are ties to ITU. Many 3GPP standards development activities are followed closely in ITU Radio communication Sector (ITU-R) and ITU Standardization Sector (ITU-T), and standards formally published by the SDO partners are cited in ITU formal documents.

Essentially 3GPP has two areas of focus. First, ensuring that past standards are corrected and where necessary and advantageous, supplemented and enhanced to meet the needs of the industry. Second, we develop new features and, once every 10 years, even a new system.

Q2 / Could you describe the role of TSG SA as well as your role as the chair of this group?

The Technical Specification Group (TSG) Service and System Aspects (SA) have an oversight function for the SA working groups. For example Working Group 1 (WG1) develops service requirements and considers how new services relate to existing standards. Working Group 2 (WG2) is responsible for system architecture, including both end to end and core network aspects. And so on.

SA manages the work of each of these bodies – making the final determination of whether to approve all output of these groups. In addition, SA has a leading role in 3GPP in that it coordinates the work of all TSGs: SA (Service and System Aspects), RAN (Radio Access Network) and CT (Core Network and Terminals).

My role as SA Chairman involves oversight over all activities in 3GPP, both from the perspective of SA working groups and the overall coordination of all TSGs. I also am involved in discussions and problems as they arise between SDOs and other organizations, and I also welcome and guide new parties joining 3GPP.

Q3 / What is 5G NR?

5G New Radio (NR) is a new radio specification developed by TSG RAN and RAN working groups. It is a significant advance over past radio network standards in several respects. First, it operates over a greater range of frequencies, which is necessary in 5G to support millimeter wave and other new spectrum domains. Second, it provides ‘forward compatibility’ to allow for quite different applications to be added without compromising compatibility.

In 5G, there is the expectation and understanding that the radio will support different service delivery characteristics for different kinds of services, essentially differentiating between enhanced mobile broadband, ultra reliable low latency communication and massive Internet of things target services. NR finally will also increase spectral efficiency over LTE, require less energy in operation and be deployed in a wider range of scenarios.

Q4 / Could you update us on how the 5G NR standardization process is progressing? What are the accomplishments made so far and what remain unsolved?

The 5G program is divided into two phases, phase 1 in Release-15 and phase 2 in Release-16. Phase 1 is further subdivided into an early drop (December 2017), the freeze of the release (June 2018) and a late drop (December 2018).

The main accomplishment so far is the specification of NR. NR is already available for commercial development in the early access release in a so called 'non-standalone' (NSA) deployment scenario, in which NR is a supplemental access to LTE and service is provided by means of the 4G core network: the Evolved Packet Core (EPC). NR as an access capable of supporting a user equipment (UE) directly, without LTE, using the new core network: 5G Core (5GC) will be complete in June 2018.

The focus of Phase 2 has yet to be determined, but there is interest in dozens of areas, mostly to improve the performance and capabilities of the 5GC and NR. It also aims at providing specific enhancements needed for new business sectors, what the 3GPP standards community calls 'verticals', including automotive, industrial automation and much more.

XUTAO ZHOU /Samsung Research China (3GPP RAN WG4, CHAIR)

Q1 / Could you describe the role of the RAN 4 Working Group as well as your role as the chair of this group?

3GPP RAN WG4 defines specifications based on operator and industry demands. It defines the radio performance requirements and test cases for terminals and base stations. The minimum requirements defined in here are used by regional regulatory bodies and certificates.

As the chair, my role consists of overseeing meetings and guiding the group to reach a consensus. I also develop plenary leaderships and 3GPP work plans with other groups. It is important that I design effective e-mail discussions, meeting arrangements, meeting agenda and other organizational aspects for each meeting.

Q2 / Could you tell us about some of the notable achievements made by your group in terms of Release-15?

In December 2017, RAN4 successfully established the first version of NR specifications v15.0.0 for UE radio frequency (UE RF), base station radio frequency (BS RF), Radio Resource Management (RRM), UE Electromagnetic Compatibility (UE EMC) and BS Electromagnetic Compatibility (BS EMC).

In 2018, RAN4 consolidated the first version of specifications and also developed the minimum requirements for SA specifications by June. We have also completed Release-15 specifications at the last RAN4 meeting (May 21-25), which will be released in June.

In Release-15, RAN4 specified the radiated requirements together with Over The Air (OTA) test methods to verify the radiated requirements for devices.

Q3 / There seems to be a growing interest for the millimeter waves spectrums across the industry. Please elaborate.

It is no longer just the operators that are interested in exploring the millimeter wave spectrum. Terminal and base station vendors now link it with their product roadmaps. In RAN4 Release-15 specifications, 4 mmWave bands in total have been defined: n257 (26,500 - 29,500 MHz), n258 (24,250 – 27,500 MHz), n260 (37,000 – 40,000 MHz) and n261 (27,500 – 28,350 MHz).

Q4 / Which frequency bands do you expect will be supported by the first 5G devices?

Since the bands included in the Release-15 specifications were specifically requested by operators, these bands will most probably be the ones supported by the first 5G devices. Considering the long time it would take to refarm LTE spectrums, the new NR spectrums—3.5GHz frequency and mmWave bands—are most likely to be supported.

That said, the availability of 3.5GHz and mmWave range differs by countries. This will ultimately determine which bands are supported by the first 5G devices in different countries. For example, the first 5G devices in US are likely to support n261 and n260bands from the mmWave range.

YOUNSUN KIM /Samsung Research (3GPP RAN WG1, VICE CHAIR)

Q1 / Could you please describe the role of RAN 1 Group as well as your role as the vice chair of this group?

RAN WG1 is a working group in 3GPP that is responsible for shaping the physical layer specification of LTE (4G) and NR (5G). We design how signals are transmitted in wireless channels. My role involves overseeing Multiple-Input Multiple-Output (MIMO), power control, and non-terrestrial network sessions in the NR track. For the LTE track, I specifically chair the LTE Vehicle-to-everything (V2X) session.

Q2 / Back in February 2017, global mobile industry leaders announced their support for the acceleration of the 5G NR standardization schedule. How did this impact your work in the past year?

It meant that the time we had left to complete NR specifications was shortened by 6 months, from June 2018 to December 2017. Our team was under an immense pressure to meet this date. There are typically 6 RAN1 meetings per year, but this jumped to 9 in 2017. It was a lot of hard work under a tight schedule. That said, we are proud to see that we have directly contributed to the creation of the actual, final NR specifications-based products.

Q3 / Could you share some of the notable achievements you have made, in terms of RAN specifically, that we can expect to see in Release-15?

There are a couple of things that can be hailed as achievements for NR Release-15. First is the support for higher frequencies (mmWave) which Samsung has led the way since 2009. Before this, there was no company that seriously considered using higher frequency bands for cellular communications. With NR Release-15, cellular communications can now reach all the way up to 52.6GHz. This is a huge leap from the highest LTE frequency which is around 6GHz. Second is the vast improvement to throughput made via multi-antenna technology (or NR-MIMO). NR-MIMO provides the specification support that allows a base station to simultaneously transmit to multiple terminals using the same wireless resources. We expect to see this game changing technology to increase the current throughput performance by a factor of 3. Third is reduced latency, which is expected to decrease by 3 to 5 times.

Q4 / What can we expect to see from Release-16?

Our 5G vision is only partially fulfilled by NR Release-15. Our vision can be divided into 2 big categories. The first is to simply make improvements to mobile broadband. The other is to generate various verticals using wireless technology. The first has been achieved in NR Release-15 with NR-MIMO and other technologies that focus on higher frequencies. Much to everyone's disappointment, we did not have the time to seriously consider the latter. I think that it will be the main area of discussion for RAN1 and the rest of the 3GPP working groups for the next few years.

RICKY KAURA /Samsung Research United Kingdom (3GPP CT WG1, VICE CHAIR)

Q1 / Could you please describe the role of CT WG1 Group?

3GPP operates a waterfall method for the development of technical standards where "stage 1" defines the requirements, "stage 2" defines the architecture standards and "stage 3" takes the requirements and architecture and creates the detailed procedures and protocols.

3GPP CT WG1 (CT1) is a "stage 3" working group made up of operators, UE vendors and network vendors representing all the SDO partners of 3GPP. It is responsible for the elaboration of the 3GPP Core and Terminals and is responsible for the protocol development between the UE and the Core Network at the Non-Access Stratum (NAS) layer and at the IP Multimedia Subsystem (IMS) layer. This includes aspects of the IMS that are common to both mobile and fixed networks. CT1 is also the principal stage 3 working group responsible for developing the protocol aspects of mission critical services. As new services emerge, as foreseen in the 5G program, CT1 will define end to end protocol aspects for these as well.

Q2 / How would core networks be changed in the 5G era?

With the need for network functions to be configured, connected, deployed and scaled in a given time, there has been a need to revisit the core network architecture. With the advent of cloud-based computing and network virtualization, there has also been a need to look at how services can be provided.

One of the main changes in the 5G core network compared to previous core networks is the introduction of the service-based architecture. Each network element is defined as a network function and offers services via interfaces of a common framework to any network functions that are permitted to make use of these provided services. This enables a more flexible development of new services.

The 5G Core network is a common Core Network which can operate with different Access Networks, for example NG-RAN and 3GPP defined untrusted WLAN access. One important change from previous releases is the development of a common NAS protocol stack that is used for both non-3GPP and 3GPP access networks.

Another aspect that affects the development of the CT1 standards is the split of the mobility management function and the session management function into different entities, the Access & Mobility Management Function (AMF) and the Session Management Function (SMF).

Network slicing is a distinct key feature of the 5G system architecture. Although LTE did support dedicated core networks, network slicing is a much more powerful concept and its introduction has an impact on the development of the NAS standards. Additionally, a new QoS model has been developed for the 5G system that enables differentiated data services to support diverse application requirements while using radio resources efficiently.

Interview with Samsung

Woojune Kim, Senior Vice President and Head of North America Sales at Networks, Samsung Electronics

Why do you think Verizon has chosen Samsung as its partner for the 5G FWA business?

From CDMA Femtocell in 2009 to LTE Femtocell in 2015, Samsung has been working closely with Verizon for many years. We have also been an active participant of Verizon's 5G Technical Forum (5G TF) which built an open, early specifications for 5G fixed wireless access. I believe that Verizon has chosen Samsung for two reasons: our long-term partnership that stretches back nearly 10 years, as well as Samsung's innovative approach with using the 28GHz spectrum for 5G.

Samsung has successfully launched the world's first 28GHz-supporting 5G FWA end-to-end solution spanning RFIC/modem chipset for the base station, device, base station, core and indoor/outdoor CPEs as device for subscribers. This is a momentous industry milestone in that it is the first 5G product to have been granted regulatory approval from the United States Federal Communications Commission (FCC).

What are Samsung's contributions to 5G NR specifications establishment?

Specifications establishment process brings together members across the industry and serves as an important foundation for 5G ecosystem. Samsung is contributing actively by holding 5 chair/vice chair positions for SA which handles the structure of the entire system, the RAN4 working group and more. Samsung has also declared the largest number of 5G patents to the European Telecommunications Standards Institute (ETSI), up to 1,254 patents.

What are Samsung's 5G business strategy and future plans?

When 3GPP finalizes 5G NR specifications in June 2018, the development of 5G network equipment and devices will start to accelerate. Samsung plans to focus on securing its position in markets like Korea, US and Japan where 5G commercialization will be initiated. This means that we will be exploring and using both below 6GHz and mmWave spectrums.

It looks like the initial stage of 5G commercialization will involve introducing 5G to the existing LTE network. How is Samsung preparing for this?

In September 2017, we had successfully completed the world's first 4G-5G interworking trial together with SK Telecom. The trial showed that users in traveling cars can be connected at all times in a 4G-5G intertwined environment by using the current 4G LTE commercial network in the 2.6GHz band and newly built 5G networks using 3.5GHz and 28GHz bands, as well as virtualized core and a test device that supports both 4G and 5G technologies. We are making sure that the 5G solutions we are developing can interwork with 4G LTE technology.

SAMSUNG

About Samsung

Samsung inspires the world and shapes the future with transformative ideas and technologies. The company is redefining the worlds of TVs, smartphones, wearable devices, tablets, digital appliances, network systems, and memory, system LSI, Foundry and LED solutions. For the latest news, please visit the Samsung Newsroom at http://news.samsung.com

For more details on Samsung, please visit; https://www.samsung.com/global/business/networks/, https://news.samsung.com/us/, or visit Linkedin @Samsungnetworks

SAMSUNG

Link to full article

https://www.gov.uk/government/publications/uk-digital-strategy/uk-digital-strategy

Policy paper

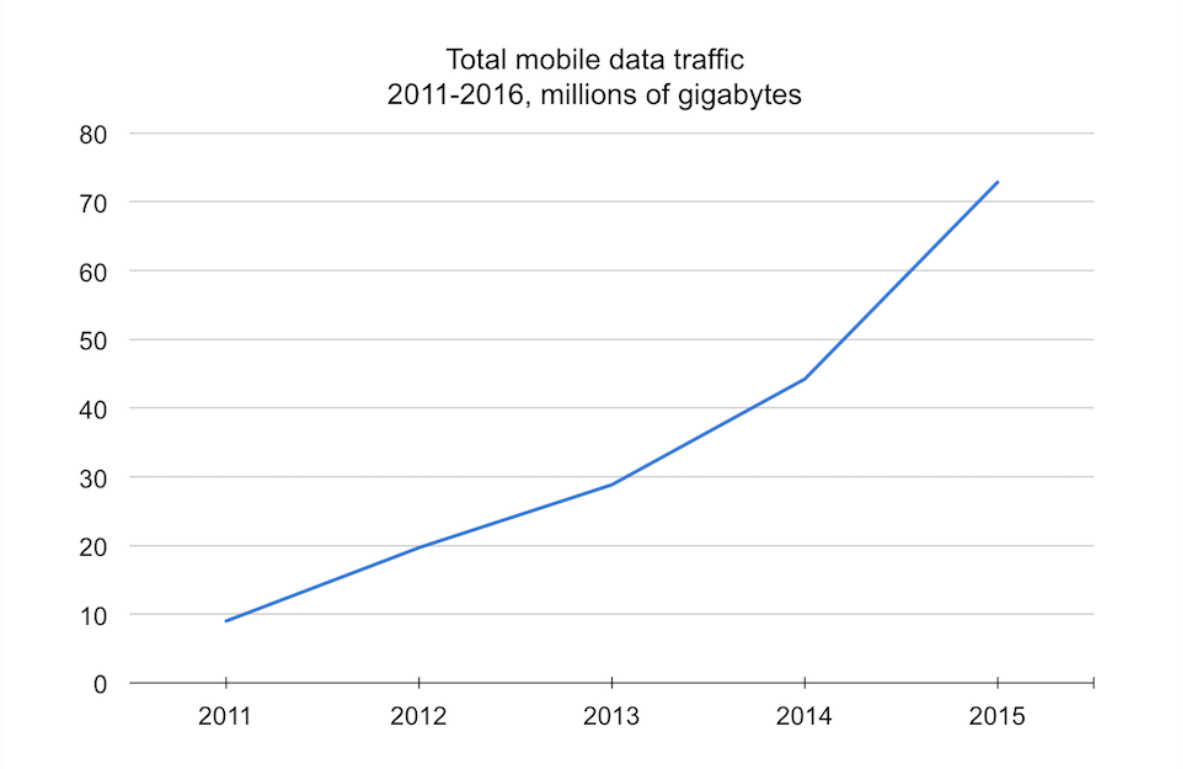
Subsection

1. Connectivity - building world-class digital infrastructure for the UK

Published 1 March 2017

Contents

By 2020, the volume of global internet traffic is expected to be 95 times that of 2005, and connected devices will outnumber the global population by nearly seven to one.[1] In the UK, fixed internet traffic is set to double every two years,[2] while mobile data traffic is set to increase further at a rate of 25% to 42% per year.[3]



Source: Ofcom Connected Nations 2016

The UK's digital infrastructure must be able to support this rapid increase in traffic, providing coverage with sufficient capacity to ensure data can flow at the volume, speed and reliability required to meet the demands of modern life. Broadband and mobile must be treated as the fourth utility, with everyone benefiting from improved connectivity. This will play a crucial role in ensuring that everyone, wherever they live and however they connect, can make full use of digital services and benefit from participation in the digital economy. Improved connectivity also increases innovation and productivity across the economy, bringing significant economic rewards. Independent research suggests increased broadband speeds alone could add £17 billion to UK output by 2024.[4]

We will also look at connectivity in a more holistic way. There are a range of technologies that can provide next generation connectivity, from fixed line broadband, to mobile, wireless, and satellite connections. But for most people, it is the quality of connection that matters, not the means of delivery. Instead of focusing on the type of technology, we will focus on what consumers - households and businesses - need and want as they go about their lives where they live, work and travel in this digital age.

Business connectivity

World-class digital connectivity is increasingly vital for businesses in the UK. For example, in a CBI survey, 81% of firms said that they see more reliable mobile connectivity as essential.[5] Now more than ever, we need to support them to grow and compete in a global environment, and to reach new customers and markets online.

We have already helped connect over 42,000 businesses through the Connection Voucher scheme. Over 80% of SMEs now have access to superfast broadband (based on Ofcom's higher measure of download speeds of at least 30 megabits per second (Mbps)) up from 68% coverage a year ago. But it is clear that more needs to be done. Business connectivity continues to lag residential connectivity, whilst 8% of small businesses, mainly in rural locations, do not have access to broadband speeds of 10Mbps or above.

We are determined to close the gap with residential properties and drive up the quality and reliability of coverage for businesses. This means ensuring that businesses are at the forefront of future broadband roll-out, including full fibre. In December 2016, we published a Call for Evidence on full fibre roll out and will publish its findings, and next steps, alongside the summary of the findings of the **Business Broadband Review**, in spring of this year.

We are also working with Ofcom to ensure the market structure for broadband delivery is right. This includes increasing transparency on the location of digital infrastructure, so that local businesses can work with the communications industry to ensure that they get the connectivity they need to thrive.

To ensure this work is fully co-ordinated, we will establish a new **Business Connectivity Forum**, chaired by the Department for Culture, Media and Sport, that will bring together business organisations, local authorities and communications providers to develop specific solutions to the issues faced by businesses in accessing fast, affordable, reliable broadband. The Forum is a recommendation of the Business Broadband Review, and further detail on its remit and membership will be set out in the Review's Summary of Findings.

Effective regulation

It is essential that we continue to create conditions that encourage investment in the UK's digital infrastructure. A strong, stable regulatory regime is at the heart of this, with Ofcom - the UK's independent communications regulator - protecting the interests of consumers, by promoting competition. Strong competition will help ensure the private sector meets consumers' needs and demands, keeps pace with technological change, and provides commercial investment in digital infrastructure.

We are also using regulation to make it faster and cheaper for operators to build and develop digital infrastructure:

- the **Access to Infrastructure Regulations** ensure digital communications providers can access other providers' physical infrastructure, across a range of sectors, on fair and reasonable terms
- reforms to **mobile planning laws** in England have reduced planning requirements, allowing new sites to be developed quicker and a greater number of small cells to be deployed
- reforms to the **Electronic Communications Code**, made through the Digital Economy Bill, will further encourage an efficient use of infrastructure by promoting site sharing

We will continue to make it easier to build digital infrastructure, for example through **exploring options around planning and wayleave agreements**. And we will ensure that our regulatory framework recognises and supports the fact that the infrastructure required to deliver connectivity is converging - particularly as we prepare for the roll out of 5G.

Improved regulation of the consumer market will also play an important role in improving connectivity. We are working with regulators and industry to ensure that **advertising for broadband** more accurately reflects the actual speeds consumers can expect to receive, rather than a headline 'up to' speed available only to a few, and accurately describes the technology used, using terms like 'fibre' only when full fibre solutions are used. There should not be a gap between what is promised by providers and what is experienced by the consumer. The non-statutory Advertising Standards Authority has already made some progress in ensuring that broadband prices are made clearer and costs to consumers are not hidden, and we will continue to work with them to ensure that the advertising of communications is accurate and fair.

Working with local communities

Local communities are best placed to identify the connectivity needs of their local area. It is therefore important that they are able to work with communications providers to shape the roll-out of digital infrastructure.

We will encourage a locally-led approach by supporting partnerships between residents and local community bodies, including schools and public libraries. A range of tools and advice - including on government's Go Superfast Checker website - are now available to make it easier for communities to identify their connectivity challenges and to establish community broadband solutions. This support includes examples of delivery models, technologies, financing options and case studies from similar communities in the UK.

Broadband Delivery UK (BDUK) also supports local authorities who want to jointly fund investment with communities to enable new infrastructure projects to go ahead. This is done in a number of different ways, for example by extending the scope of existing contracted plans by sharing the full cost of going further into high-cost areas.

Better connectivity for all

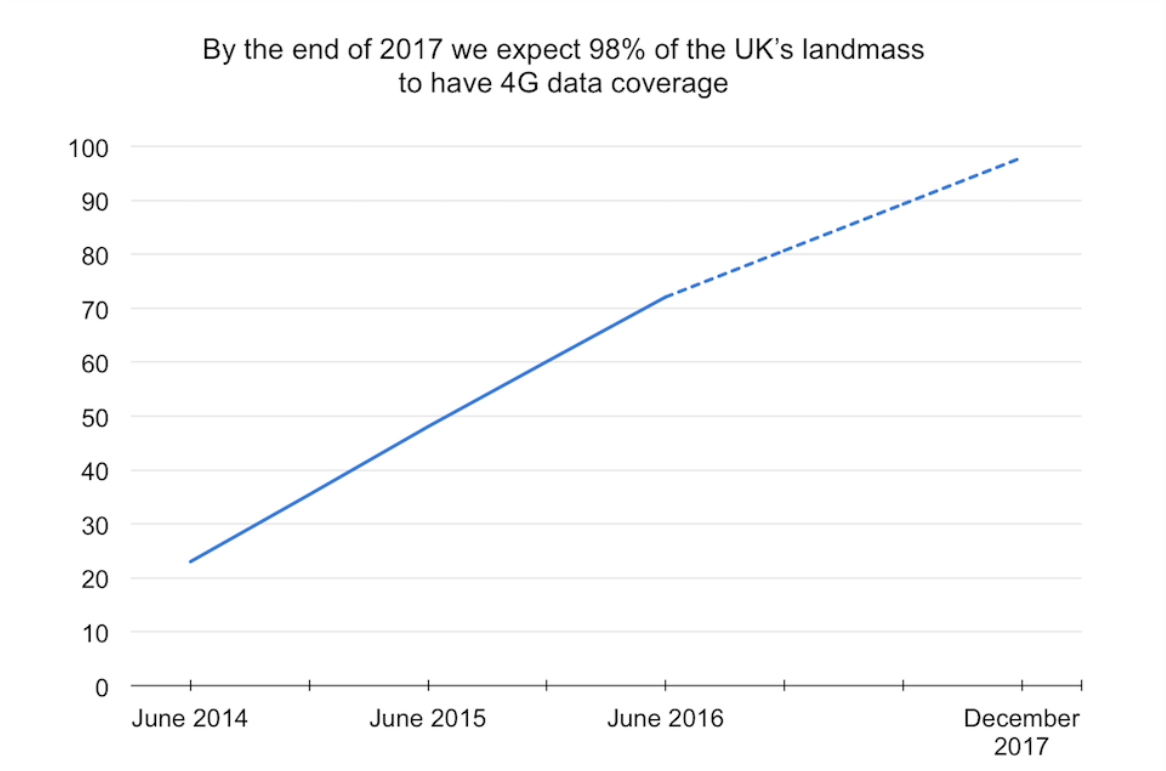
Broadband

£1.7 billion of public funding is already being invested in delivering broadband across the country. Over 90% of UK premises can now access superfast broadband, and we are on track to reach 95% of UK premises by December 2017. Through strong contractual value for money requirements, we have released additional funds to extend delivery, with 600,000 more premises expected to benefit by 2020.

We recognise that there will always be some premises that cannot be connected on a commercial basis. For families, public services and businesses in these hardest to reach areas, we want to ensure that everyone can access fast, reliable broadband. This is why we have committed to introducing a **new broadband Universal Service Obligation (USO)** by 2020. The USO will give every individual, business and public premise across the country the right to request an affordable high speed broadband connection, at a sufficient speed for an average family to make full use of the internet, up to a reasonable cost threshold. The legislation to enable us to do this - the Digital Economy Bill - is currently before Parliament. In December Ofcom published technical advice to government on the factors that will help inform the design of the broadband USO. We will carefully consider Ofcom's findings before consulting on secondary legislation in early 2017. The terms of the USO will be regularly reviewed to ensure it keeps pace with consumers' changing needs.

Mobile

The licence obligations arising from the December 2014 agreement between the government and industry have already locked in investment of over £5 billion to improve mobile coverage. Ofcom's 2016 Connected Nations Report shows that 99% of UK premises now have indoor voice coverage and 96% have indoor 4G data coverage. And the report notes that 4G geographic coverage has increased substantially over the past year from 48% to 72% and this is set to increase yet further.



Source: Government estimates

As the recent National Infrastructure Commission report on the future of mobile connectivity set out, it is essential that outdoor mobile services - such as basic talk, text and data - are available wherever we live, work and travel. All four Mobile Network Operators each now have a legally binding obligation to reach at least 90% landmass coverage by the end of this year. Ofcom is responsible for enforcing these obligations and, through the Digital Economy

Bill, will have the power to fine companies that do not meet them. By the end of 2017 we therefore expect 98% of the UK's landmass to have 4G data coverage and at least 98% of UK premises to have indoor 4G coverage from at least one operator.

But we also recognise that we must go further to make better coverage and quality a reality for everyone across the UK. Government understands that the everyday experience of connectivity is important, not just the statistics. Where necessary to meet our ambitions, we will consider whether future auctions of radio spectrum should include commitments to increase coverage and reliability. Through the Digital Economy Bill we are also giving consumers greater clarity on services in their area by giving Ofcom powers to share data on coverage and network performance. Empowering consumers with better information will help them make informed choices on the best network for them and will promote competition to deliver improved connectivity for consumers.

Transport

Commuters on the UK's train networks expect good connectivity on the move. Wi-Fi is being rolled out on trains across the UK, and we forecast that 90% of passenger journeys on Department for Transport-franchised lines will benefit by the end of 2018. We are taking steps to drive progress towards faster and more reliable free Wi-Fi across the train network. In new rail franchises, train operators will be required to tackle 'not-spots' on their routes and deliver high-speed connectivity to ensure Wi-Fi is fast and reliable across routes serving the majority of their passengers, so they can send emails, browse the web and social media, and make calls using Wi-Fi calling.

Coverage on UK motorways is high, with 97% receiving voice coverage from all operators.[6] But significant improvements are needed to ensure there is a reliable connection across other major roads, not only so that consumers can make a call while on the move or in an emergency, but also as a means of enabling applications from real-time traffic alerts to emerging technologies such as connected and autonomous vehicles and smart motorways.

The **Emergency Services Mobile Communication Programme** is an important step in this process. By opening up this infrastructure for commercial use as far as possible we will extend coverage across the UK, including improving commercial coverage on roads.

Networks of the future: full fibre and 5G

We have to encourage the market towards ubiquitous ultrafast services but balance the additional benefits of increasing speed against the costs today of providing the infrastructure. Government has an important role to play to accelerate and de-risk the deployment of the next generation of digital infrastructure - setting the structures; supporting experimentation and testing; helping to reduce the costs; and above all for leadership and setting ambition. **At Autumn Statement 2016 we made a clear commitment to digital connectivity, including the allocation of £740 million from the National Productivity Investment Fund to support the market to roll out of next generation digital infrastructures.**

Delivering ultrafast speeds

There are existing networks that are capable of delivering ultrafast speeds (at least 100Mbps). Trials have demonstrated that G.Fast can provide ultrafast connections to premises up to around 300 metres from the cabinet - around 70% of premises. Cable (primarily provided by Virgin Media) is capable of delivering at least 200Mbps now, and there are plans to increase that speed. And the next iterations of each - XG.Fast and DOCSIS 3.1 - will give consumers even faster speeds.

Full fibre

Whilst there are a number of interim technologies giving connectivity at ever faster speeds, we believe that the future of high-speed and high-quality connectivity lies in deeper, more extensive fibre networks. To promote this, we will invest **£400 million in a new Digital Infrastructure Investment Fund, which we anticipate will be more than matched by private sector investors**. This new fund will catalyse the market for alternative full fibre providers by ensuring that they can access the finance they need to help scale the UK market for full fibre broadband.

We are also making further public funding available for the roll-out of full fibre broadband networks in partnership with local authorities across the UK. In December we published a Call for Evidence to ask stakeholders to consider and provide information on a series of options to support this deployment. The Call for Evidence has now closed, and further detail on next steps will be published at the Spring Budget 2017.

Public owned or funded networks, such as the Janet academic and research network, and Network Rail, offer another potential route to increase fibre connectivity. We will look at how these can be opened up to provide vital ‘backhaul’ infrastructure. This could help reduce the cost of fibre roll-out and consequently increase business and residential connectivity in hard to reach areas.

Our 5G Strategy

5G is the next generation of mobile connectivity, and is currently in development. It is expected to represent a significant upgrade: providing ultrafast, low latency, and more reliable mobile connectivity, able to handle our ever-increasing data requirements. This should present huge opportunities to boost productivity and grow the economy. In addition to giving consumers and business users high quality connectivity, it will also support the development of the Internet of Things: the rapidly-increasing number of connected devices, from connected cars to digital health applications. New fibre infrastructure will play a crucial role in the future deployment of 5G, which is likely to require extensive use of small cells (essentially mini base stations), connected to the core network by backhaul (usually a fibre connection).

We want the UK to take a leading role in the development and roll-out of 5G. If the UK is going to be at the forefront of the 5G revolution it will require concerted action from government, industry, academia and local areas both to develop the technology and deploy the networks to support it. We are developing a 5G Strategy, to be published at Spring Budget 2017, which will set out our vision for the next generation of mobile connectivity, and the steps we will take to realise that vision.

5G and fibre testbeds

As part of the £740 million of investment in digital infrastructure announced at Autumn Statement 2016, we will fund a coordinated programme of integrated fibre and 5G trials to help make sure that we are in the best possible position to exploit the considerable potential of 5G and future digital services for UK consumers and businesses.

Spectrum for connectivity

Better use of radio spectrum will also facilitate further investment and innovation in 5G technologies. We will deliver on our commitment to **free up 750 MHz of public sector spectrum** in bands below 10 GHz by 2022, having already made over half (384 MHz) available to use since 2010.

This includes continuing the approach set out in the 2014 Spectrum Strategy of charging government departments a market-based fee for their spectrum use, encouraging spectrum sharing and wherever possible making suitable spectrum available for advanced communications technologies such as 5G.