Case study
Orange Romania

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5G for Fixed Wireless Access

Introduction

5G technologies will revolutionize wireless services and connected devices. With blazing speed, ultra-low latency, and massive connectivity, these technologies will enable a world of connected devices, working seamlessly together for consumers to make life more manageable, safer, and a whole lot more fun. Drawing on their long legacies of innovation, Orange, Samsung and Cisco are leading the way to develop these transformative 5G solutions.

One of these key solutions is broadband access, which is vital to socio-economic development. Deploying wireline broadband networks requires high capital expenditure and mid- to long-term investments. In particular, the last mile deployment has been a major obstacle for wireline broadband technologies. A solution to time consuming and costly last mile deployment is Fixed Wireless Access (FWA). FWA allows carriers to meet increasing demands for high speed broadband with shorter time to market and more cost-effectively.

FWA solutions using LTE or WiMAX have been around for many years but the achieved speed is not nearly as fast as other high speed broadband solutions (e.g. fixed). Recently, millimeter wave (mmWave) technologies for commercial communications have experienced a phenomenal development within the scope of 5G. Frequencies ranging between 6 and 100GHz have been recently identified as a key enabler to effectively achieve the ITU IMT-2020 requirements for 5G as a comparison to those established for IMT-Advanced for 4G.

These high frequencies have become available opening up considerable amounts of capacity thanks to important advancements in massive antenna technologies, which allow a sophisticated beamforming.

The first 5G mmWave FWA commercialization took place on October 1st, 2018[1)] with the specific use case of FWA promising "typical speeds of around 300Mbps and peaks of up to 940Mbps at home"[2)]. Thus, mmWave 5G may arise as a perfect alternative to fibre when the deployment of the latter is impossible or hard to materialise. The Figure 1 below summarises the current wireline technologies employed in the last mile, compared to mmWave FWA.

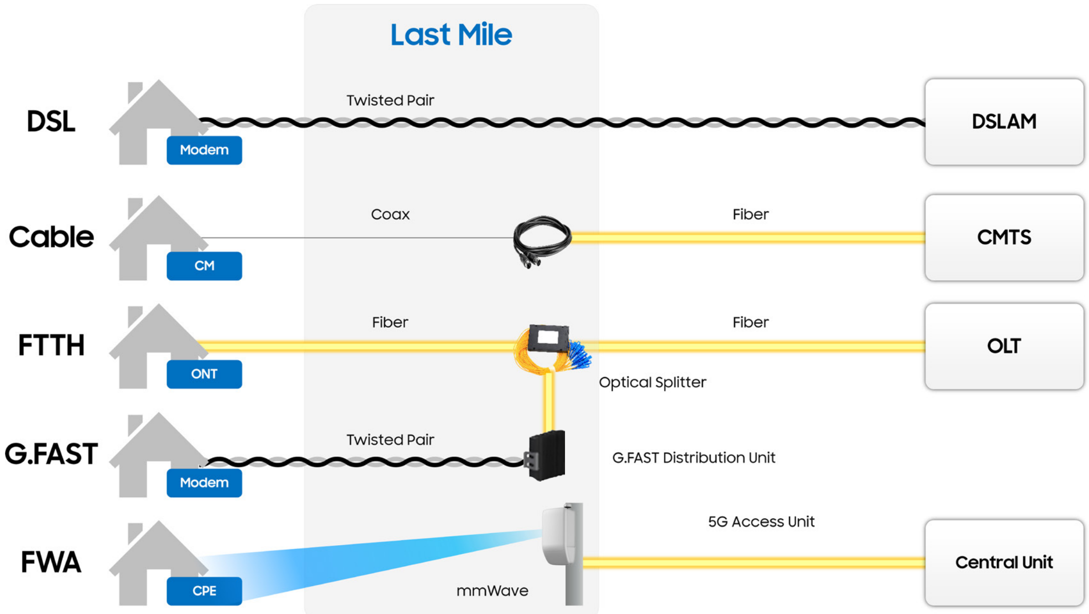


Figure 1: Wireline technologies compared to mmWave FWA

[1)] Verizon turns on world's first 5G network at https://www.verizon.com/about/news/verizon-turns-worlds-first-5g-network
[2)] Verizon Wireless' 5G Home FAQs at https://www.verizonwireless.com/support/5g-home-faqs/

5G FWA Technology

Spectrum allocation

mmWave bands in 26 GHz and 28 GHz should have high priority for early 5G implementation. Recently, 3GPP has adopted the following bands as 5G NR bands[3], as illustrated in Figure 2.

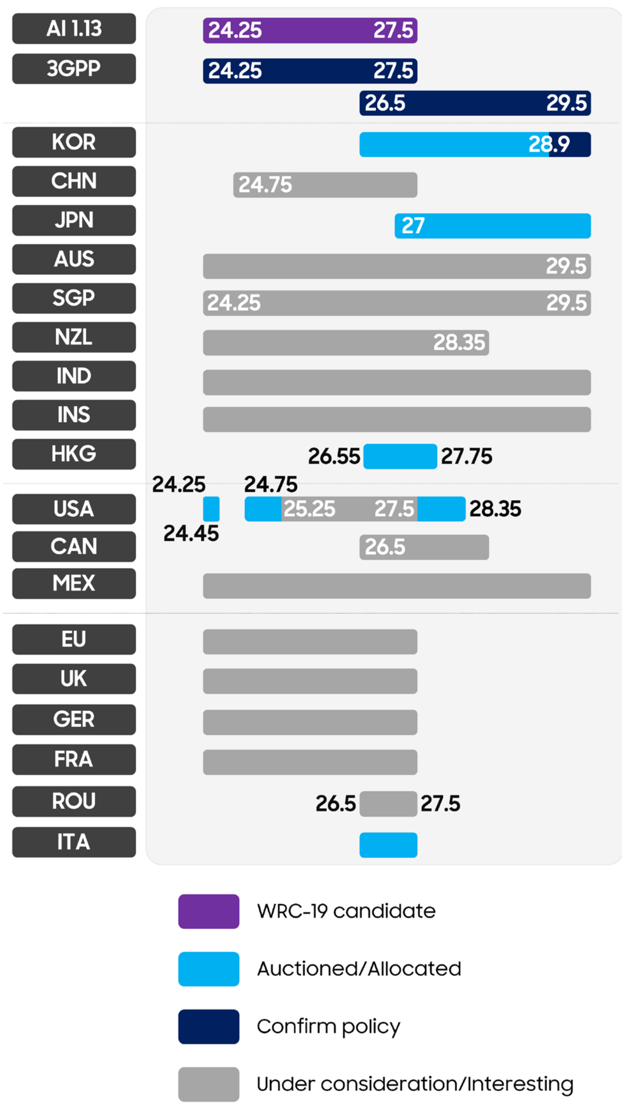
- n257 (26.5 – 29.5 GHz, so called 28 GHz band and 5G Frontier band)
- n258 (24.25 – 27.5 GHz, so called 26 GHz band and 5G Pioneer band)
- n260 (37GHz – 40 GHz as included in TS38.104)
- n261 (27.5 – 28.35 GHz)

In June 2018, 3GPP finalized its work to develop the technical specifications to support these frequency bands within the timeframe of Release 15.

Some European countries, e.g. the UK and Italy, conducted consultation processes to make upper portions of 26 GHz, i.e. 26.5 – 27.5 GHz, available before 2020. Significantly, in January 2018 Europe has committed to make at least 1 GHz of mmWave spectrum available by 2020 and this is widely expected to be 26.5 – 27.5 GHz. This band overlaps both the 26 GHz band and 28 GHz bands.

To date, the USA has already commercialized 5G in the 28 GHz band (27.5 – 28.35 GHz) with 5G FWA deployments commenced in 2018. Korea made available 28 GHz (26.5 – 28.9 GHz) in March 2019 and Japan will commercialize 28 GHz (27.0 – 29.5 GHz) during 2020.

Figure 2: Global 5G Spectrum Outlook in 26-28 GHz frequency range



As of May 2019
This figure has been developed based on various sources of information.
This figure may require updated information.

Taking into account the above-mentioned and Figure 1, Orange, Samsung and Cisco recognize that 5G using 26 GHz or 28 GHz bands, depending on location, is an essential component that will be necessary to support 5G services delivering fiber-like FWA services.

[3] TS38.104 Base Station (BS) radio transmission and reception (Release 15).

Beamforming

Traditional radio methods provide broad coverage, but present challenges at high frequencies. Low frequencies travel far and penetrate objects easily, which has enabled good coverage with relatively basic antenna technologies. However, simple antenna designs are inefficient and new antenna technologies can avoid a lot of wasted energy. These new technologies are necessary to increase range when using high frequencies.

High frequencies, are more easily absorbed by the air and therefore more energy than that used at low frequencies would typically be needed to cover the same area.

Beamforming solves this problem by focusing the radio signal into a tight beam that actively targets each device as shown in Figure 3.

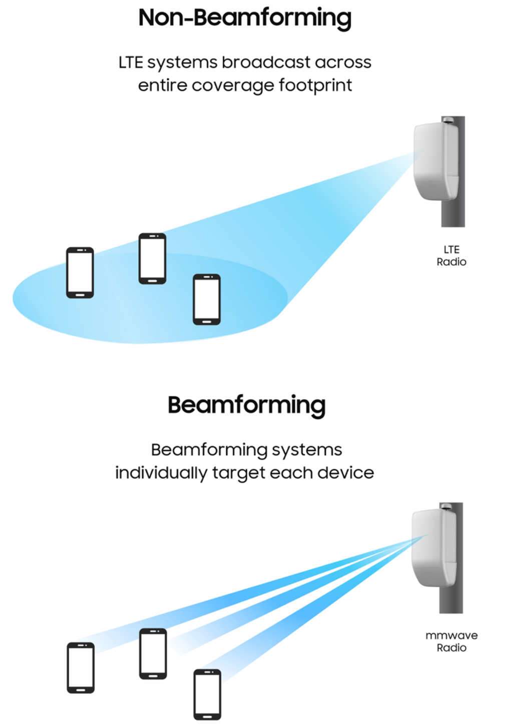


Figure 3:
Traditional antenna radiation vs. Beamforming

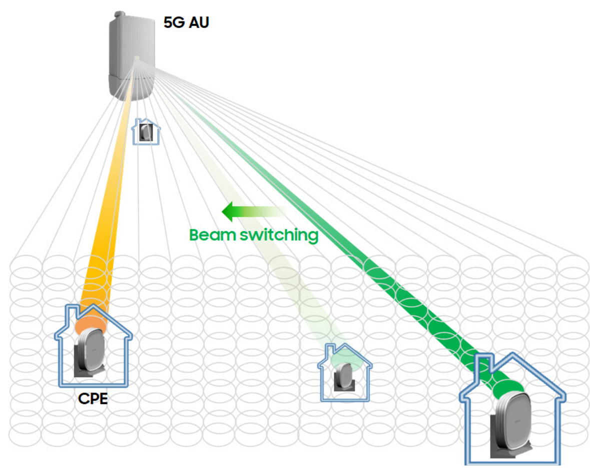


Figure 4: Beam switching

The radio system can simultaneously target several of these targets, entirely focusing the radio energy on them, in order to overcome range limitations. In order to cover the whole grid, beams rapidly switch between each device following a scheduling algorithm, as illustrated in Figure 4.

FWA Devices

The CPE serves as the user terminal, receiving the 5G signal from the AU and providing Ethernet connectivity to the Local Access Network (LAN), thus the CPE represents the 5G equivalent of a cable or DSL modem.

Figure 5 : Indoor CPE, Outdoor CPE

Samsung's first generation commercial 5G CPE targets the same frequency band as the 5G AU.

Customers have a choice of deploying either indoor or outdoor CPE depending on their house environment. The outdoor CPE can be deployed in a low e glass case or a case with poor window facing to the AU.

Virtualized Radio Access Network

Figure 6 : Access Unit

Figure 6 illustrates the appearance of the Samsung Access Unit (AU) working on the 28GHz band. With roughly 10Kg weight and 10L volume, the AU has a maximum capacity of 10 Gbps.

More than 1,000 antenna elements are used to form sharp beams and compensate for the high losses in the mmWave domain. These beams can transmit the useful signal where it is really needed.

The 5G FWA AU utilises a Functional Split Option 2, which means that all real time protocols (PHY, MAC and RLC) are included in the unit together with the RF and antenna parts, whereas non-real time protocols, i.e. PDCP and RRC, adopt a virtualised approach in vRAN, as illustrated in Figure 7.

Samsung 5G vRAN VNF can run on various types of computing hardware, including COTS equipment.

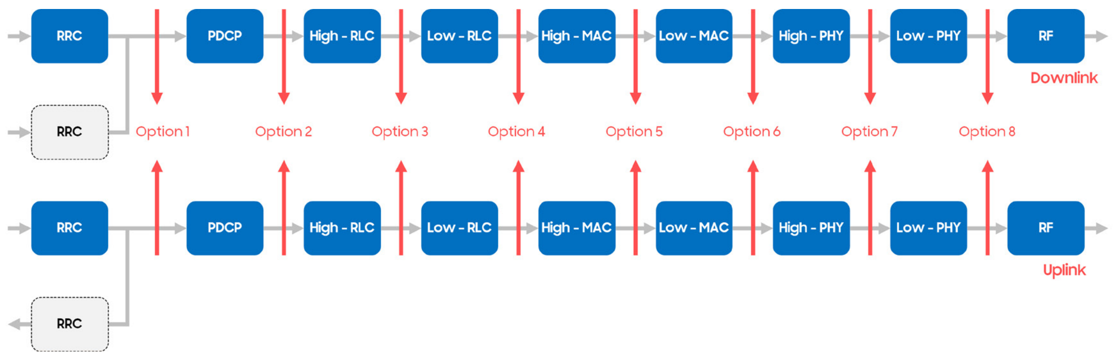


Figure 7 : Radio Access Functional Split

Virtualized Mobile Core Network

Cisco Ultra Services Platform which includes the Ultra Packet Core (UPC), Cisco's fully virtualized mobile packet core, was used for the experiment. The UPC is a full-featured packet core and widely deployed supporting over 70 million users. It is compatible with Samsung RAN via a standard S1 interface. (i.e. MME, S/PGW) used to interconnect with Samsung RAN via a standard S1 interface.

To provide the data throughput, it has been decided to deploy core in line with the 3GPP standardized Control User Plane Separation (CUPS) architecture.

This allows to dedicate resources to the user plane thereby guaranteeing highest speed for the user. Although this was not the case for the trial, it can allow to deploy user plane functions close to the radio site and while centralizing the control plane. This allows to optimize the latentcy of the service.

Cisco UPC was deployed on top of Cisco NFVI solution (aka CVIM – Cisco Virtualized Infrastructure Manager) which was provided as a movable rack on wheels and was shipped preconfigured to the trial site location.

5G FWA Friendly User Trial in Romania

Trial Description

The objective of the Friendly User Trial in Romania was to put 5G FWA to the test in a European environment so we could collect valuable information in terms of performance, installation, customer voice and so on.

We used Samsung's commercial 5G FWA Radio Access equipment, including a virtualised RAN, Access Units and CPEs together with Cisco's virtual Packet Core and Orange Romania's infrastructure, as illustrated in Figure 8.

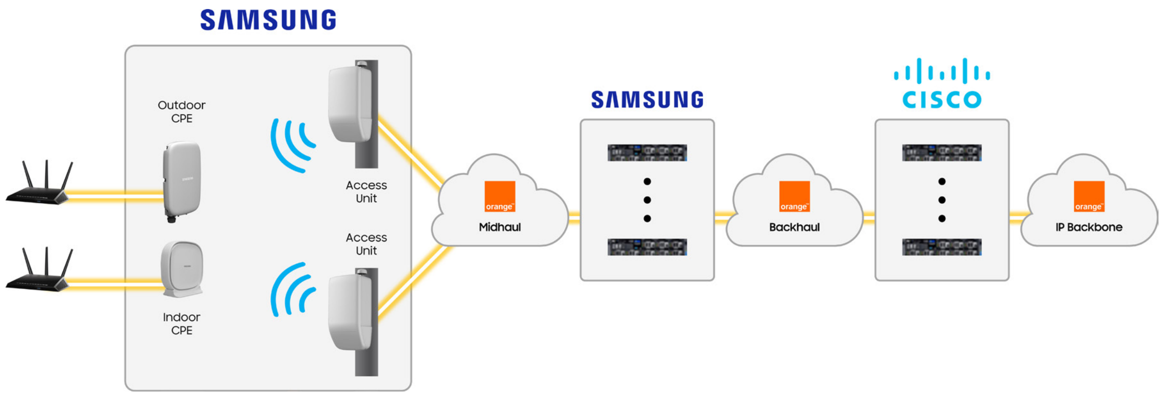


Figure 8 : Orange Romania 5G FWA Friendly User Trial Architecture

As illustrated in Figure 9, 500MHz within the 26.5 and 27.5 band was used for the Trial, which translated into an aggregated capacity of 6.25 Gbps.

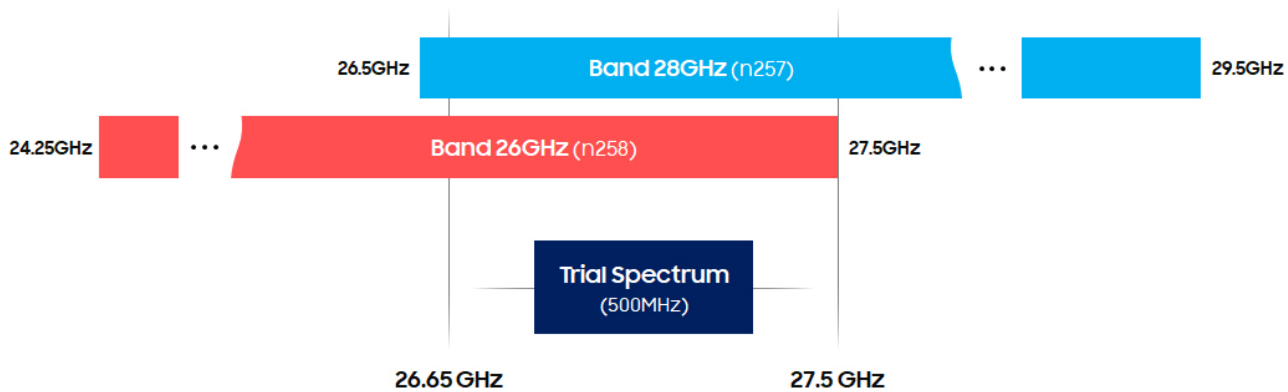


Figure 9 : Trial Spectrum

The selected location for the Trial was Floreşti, a fast-growing residential area on the West of Cluj, the second biggest city in Romania.

Due to a spectacular urban development, the area presents gaps in terms of fixed broadband infrastructure and has a large base of existing 4G FWA customers.

3D Radio Planning Results and Verification

Proper planning tools are required to make mmWave networks viable as we need to understand coverage before deploying the network and look for the best cell site locations.

One of the objectives of this trial was to check the accuracy of the planning tool developed by Samsung, which is based on raytracing analysis.

The tool makes use of advances in Artificial Intelligence and computing power to predict with a high level of accuracy the coverage in a given area.

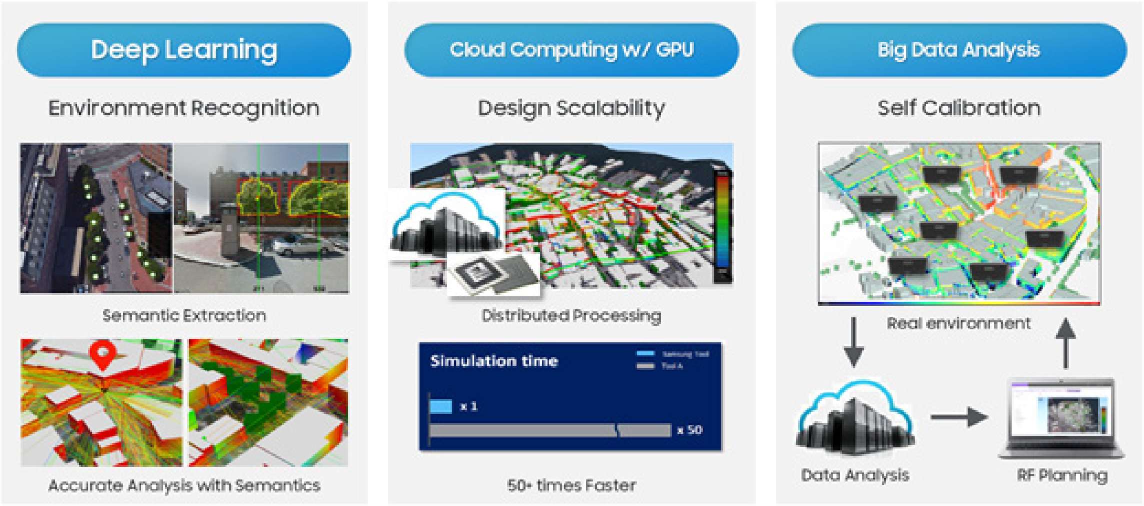


Figure 10 : 3D Planning Tool Phases

Two AUs were used in the trial, namely: Cell15 corresponding to a 22-m rooftop site pointing at the same direction as Floreşti's main road, running from East to West, and Cell17 installed in a 15-m tower pointing Northwards.

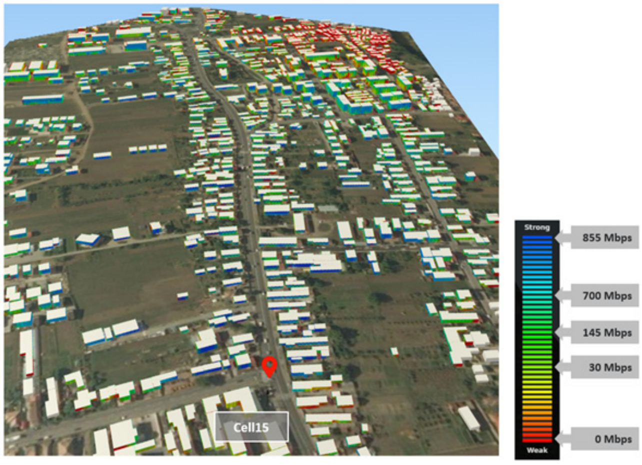


Figure 11 :

Cell15 Radio Planning Results (260° azimuth)

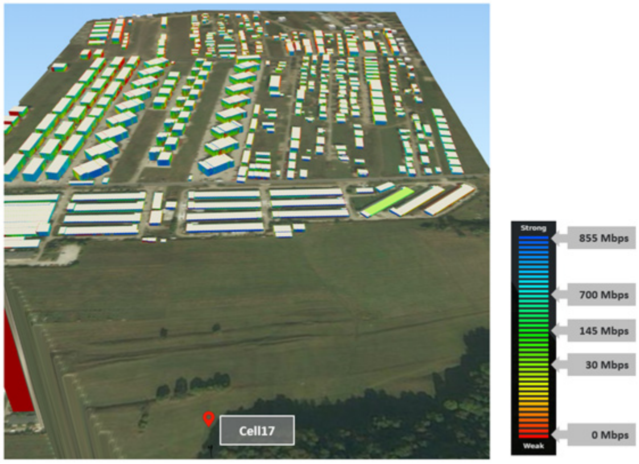


Figure 12 :

Cell17 Radio Planning Results (0° azimuth)

Trial Results

Installation Experience

The installation of the equipment was relatively easy for two reasons: the selected cell-sites were already connected with fiber backhaul and the 5G AU is small, light and easy to install.

Figure 13 :

Cell15 Rooftop and AU Location

Figure 14 :

Cell17 Tower and AU Location

Voice of Customer

Both B2C & B2B testers said that the 5G solution was as good as or better than that of their current provider. Overall performance was considered to be similar or better to that obtained from cable internet from various suppliers.

The solution was tested on a variety of devices (laptops, desktops, smart TV, smartphones, tablets) in a wide variety of activities: search on the internet, YouTube video clips, emails, online music, gaming, movies watching.

All testers said they would recommend & highly recommend Orange's 5G internet solution.

The 5G solution was used simultaneously, with good results in terms of connection speed & stability.

“This was a test that brings us closer to the future,” said Liudmila Climoc, CEO of Orange Romania, “an opportunity to better understand how the 5G technology performs in real-world use, the challenges that may arise in the implementation of new technologies and the benefits it can bring our residential or business customers.”

Figure 15 :

Outdoor CPE installed in the residence of a friendly user

Figure 16 :

Indoor CPE installed in the residence of a friendly user

Performance Results

CPEs in good radio conditions

Samsung CPE ID	Service Cell	Distance from AU (m)	CPE Type LoS/NLoS	BRSRP (dBm)	DL / UL Speed (Mbps)	SINR (dB)	Latency (ms)
S613C50450	Cell15	160	Outdoor/LoS	-74	856 / 330	22	11
S614200325	Cell15	530	Outdoor/LoS	-76	917 / 354	24	12

Samsung CPE ID	Service Cell	Distance from AU (m)	CPE Type LoS/NLoS	BRSRP (dBm)	DL / UL Speed (Mbps)	SINR (dB)	Latency (ms)
S614200305	Cell17	321	Outdoor/LoS	-75	860 / 114	24	12
S614200322	Cell17	763	Outdoor/LoS	-77	901 / 140	22	11
S613C50457	Cell17	390	Outdoor/LoS	-79	918 / 153	22	12

CPEs in medium radio conditions

Samsung CPE ID	Service Cell	Distance from AU (m)	CPE Type LoS/NLoS	BRSRP (dBm)	DL / UL Speed (Mbps)	SINR (dB)	Latency (ms)
S613C50439	Cell15	781	Outdoor/LoS	-84	621 / 170	N/A	12
S614200310	Cell15	722	Outdoor/LoS	-85	952 / 169	22	12

Samsung CPE ID	Service Cell	Distance from AU (m)	CPE Type LoS/NLoS	BRSRP (dBm)	DL / UL Speed (Mbps)	SINR (dB)	Latency (ms)
S614200315	Cell17	1119	Outdoor/LoS	-84	954 / 70	21	11

CPEs in poor radio conditions

Samsung CPE ID	Service Cell	Distance from AU (m)	CPE Type	BRSRP (dBm)	DL / U Speed (Mbps)	SINR (dB)	Latency (ms)
S614367088	Cell17	321	Indoor/LoS	-93	667 / 67	20	12
S614367109	Cell17	452	Indoor/LoS	-94	491 / 137	17	9
S76D0111	Cell17	358	Indoor/LoS	-96	711 / 18	13	9
S613C52804	Cell17	560	Indoor/LoS	-98	939 / 141	12	15
S613C52805	Cell17	475	Indoor/LoS	-98	807 / 132	15	14
S613C50459	Cell17	847	Outdoor/NLoS	-100	342 / 4	11	12
S614367101	Cell17	400	Indoor/NLoS	-102	521 / 64	0	11

[4)] Latency is defined as round-trip time in milliseconds, as can be obtained with Ping

Conclusions

- Customer feedback was overwhelmingly positive, with some users reporting a better experience than on their current fixed broadband services.
- The AU performance counters show that Cell15 is the better performing AU due to the improved RF environment experienced by the CPEs.
- Cell15 (rooftop) has better throughput, higher data volumes, better RSRP, CQI, Rank Indicator & Measurements.
- Cell17 (hilltop) performance was hindered by the NLoS conditions and a number of distant CPE locations.
- LoS CPEs, both outdoor and indoor, delivered a solid DL performance almost regardless of radio conditions, whereas UL performance was more dependent on radio conditions– the reason is DL beamforming.
- NLoS Outdoor CPE showed a decent performance providing current fibre-like service levels on DL.
- Outdoor-to-Indoor Loss did have an impact in the RSRP, with values between -90 and -100dBm. Even then DL performance was acceptable but UL suffered.
- RF Planning simulation is in line with the results obtained in the field.

Glossary

3GPP	3G Partnership Project
AU	Access Unit
BRSRP	Beam RSRP
CPE	Customer Premises Equipment
COTS	Commercial Off The Shelf
DL	Downlink
EPC	Evolved Packet Core
FWA	Fixed Wirless Access
ID	Identifier
LOS	Line of sight
MAC	Medium Acces Protocol
MME	Mobility Management Entity
NFVI	Network Function Virtual Infrastructure
NLOS	Non-line of sight
PDCP	Packet Data Convergence Protocol
PHY	Physical Layer
NR	New Radio – 3GPP 5G
RAN	Radio Access Network
RLC	Radio Link Control
RRC	Radio Ressource Control
RSRP	Reference Signals Received Power
SINR	Signal-to- interference-plus-noise ratio
S/PGW	Serving/Packet Gateway
THP	Throughput
UL	Uplink
vPC	Virtual Packet Core
vRAN	Virtual Radio Access Network

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