ASIA-PACIFIC TELECOMMUNITY

The 28th Meeting of the APT Wireless Group (AWG-28)

06 – 14September 2021, Virtual/Online Meeting

Document No:
AWG-28/INP-IAFI-11

28 August 2021

ITU-APT Foundation of India (IAFI)[1]

COMMENTS ON THE PRELIMINARY DRAFT NEW APT/AWG REPORT TOWARDS STUDIES ON 5G IMPLEMENTATION IN FREQUENCY BANDS ABOVE 24.25GHZ

Background

At its 27th meeting, the AWG received 2 contributions towards this item. Extensive discussions were conducted, views were clarified; however, no agreement could be achieved on this issue. Therefore, the two contributions were carried forward to AWG-28 for further consideration by the Sub-Working Group IMT

Discussions

mmWave bands are crucial for the success of IMT-2020 (5G) mobile communications especially in aspect of broad bandwidth and low latency. With the outcome of WRC-19 agenda Item 1.13, frequency bands in 24.25-27.5GHz, 37-43.5 GHz and 66-71 GHz have been identified to IMT globally with several technical conditions defined in several Resolutions in the Radio Regulations to protect other services.

3GPP has developed mm wave bands for the development of 5G services. mmWave spectrum is extremely important to provide high data rate and capacity, complementing the sub-6 GHz band that deliver the coverage.

With such trend, a new study on how to deploy 5G systems in mmWave bands taking into account the allocations and operations of systems in other services will be helpful. Such study could include technical and/or regulatory conditions for the coexistence of 5G systems with other services, case studies of countries that have already deployed or decided to use these bands for 5G and other information that could help other countries to deploy 5G systems in mmWave bands. This new report could provide useful information and case studies for guidance of APT Members.

Proposal

This contribution proposes some comments on the compilation document for consideration by AWG-28

[1] ITU-APT Foundation of India (IAFI) is a new Affiliate member of APT. Details of IAFI can be seen at itu-apt.org

Contact: Email:

Original Source: AWG-26/TMP-25
Compiled with:
INP-43(Inmarsat and multi companies),
INP-48(Samsung and multi companies)

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW APT/AWG REPORT TOWARDS STUDIES ON 5G IMPLEMENTATION IN FREQUENCY BANDS ABOVE 24.25GHZ

[Editor's Note: The track changes shown in this working document are compiled based on input contributions to AWG-26 but the contents were neither agreed nor reviewed due to insufficient time during AWG-26. APT members are encouraged to review the content of this working document at the next meeting.]

1 Introduction

mmWave bands are crucial for the success of ~~IMT-2020 (~~5G~~)~~ mobile communications especially in aspect of broad bandwidth and low latency. With the outcome of WRC-19 agenda Item 1.13, frequency bands in 24.25-27.5GHz, 37-43.5 GHz and 66-71 GHz have been identified to IMT globally with several technical conditions defined in several Resolutions in the Radio Regulations to protect other services.

Taking into account varied circumstance and environment as well as needs, frequency range 24.25-29.5 GHz or portions of thereof has been allocated or are being considered for 5G service. Based on these situations, 3GPP has adopted both 26 GHz and 28 GHz for the development of 5G services. mmWave spectrum is extremely important to provide high data rate and capacity, complementing the sub-6 GHz band that deliver the coverage.

With such trend, a new study on how to deploy 5G systems in mmWave bands taking into accountthe allocations and operations of systems in other services will be helpful. Such study could include technical and/or regulatory conditions for the coexistence of 5G systems with other services, case studies of countries that have already deployed or decided to use these bands for 5G and other information that could help other countries to deploy 5G systems in mmWave bands. This Report provides useful information and case studies from the globe to APT Members.

2 Scope

[Editor's Note: The description of the scope may need to be reviewed based on the content of the following sections.]

This report addresses the studies of current or intended implementation of 5G in the frequency bands above 24.25 GHz focusing on the following aspects:

- Global trends of 5G implementation,
- On-going specification developments by 3GPP (currently, in the 24.25-27.5 GHz, 26.5-29.5 GHz, 37-40 GHz, and 39.5-43.5 GHz bands),
- ITU-R studies and developments of 5G systems
- On-going industry developments,
- Case studies in those countries that have implemented or plan to implement 5G.

3 Vocabulary of terms

[TBD]

4 References

[TBD]

5 Global trends of 5G implementation

[Editor's Note: This chapter provides5G implementation progress in the frequency bands above 24.25 GHz in global area and could provide the relevant information to Asia Pacific countries.]

The World Radiocommunication Conference 2019 (WRC-19) have identified additional radio-frequency bands for International Mobile Telecommunications (IMT), which will facilitate the development of fifth-generation (5G) mobile networks. In total, 17.25 GHz of spectrum has been identified for IMT by the Conference, in comparison with 1.9 GHz of bandwidth available before WRC-19.While identifying the frequency bands 24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz for the deployment of 5G networksIMT, WRC-19 also took measures to ensure an appropriate protection of the Earth Exploration Satellite Services, including meteorological and other passive services in adjacent bands, in accordance with Resolutions 241 (WRC-19), 242 (WRC-19), 243 (WRC-19), 244 (WRC-19) and 750 (Rev.WRC-19).

In total, 17.25 GHz of spectrum has been identified for IMT by the Conference, in comparison with 1.9 GHz of bandwidth available before WRC-19.

In addition, to the band identified at the WRC-19 for IMT, several countries such as Canada, Japan, Korea, New Zealand, Singapore, USA have either licensed or are considering parts of 26.5-29.5GHz to 3GPP based 5G technology, based on their spectrum availability and equipment readiness from mobile industry.

mmWave spectrum is extremely important to provide high data rate and capacity, complementing the sub-6 GHz band that deliver the coverage. Current situation of various administrations from various regions is provided below on their plans on spectrum between 24.25 to 29.5 GHz. Consideration, Identification, and assignment of the band between 24.25 to 29.5 GHz by the administrations have been mentioned below [4].

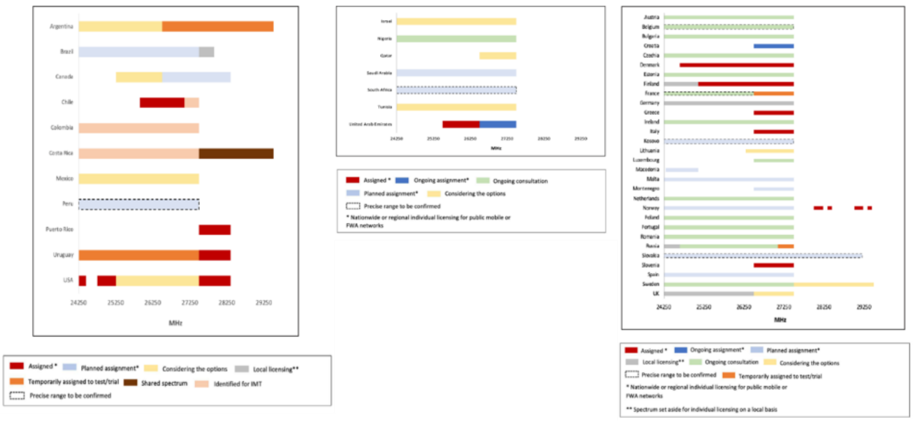


Table 1 : High band 5G licensing status of America and Europe

Delete Table 1

Table 2 : High band 5G licensing status of Asia

Delete Table 2

Device ecosystem in the mmWave band (especially 3GPP bandsin n257, n260, and n261) is growing as mentioned below and it is comparative with ecosystem of other 5G bands.

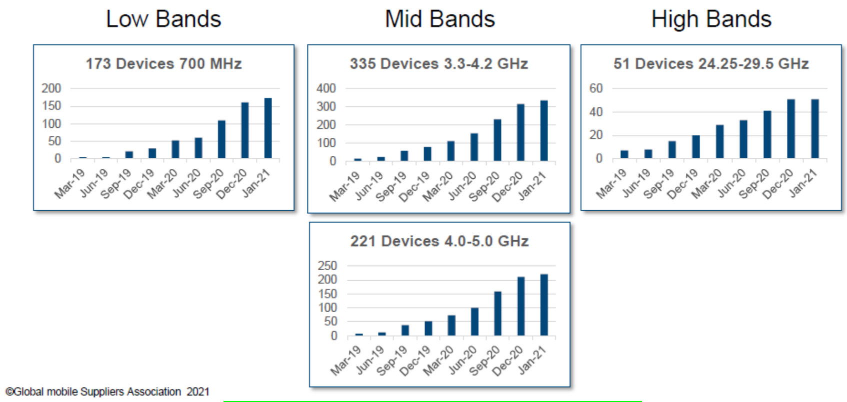


Table 3 : Device ecosystem in 3GPP bands.

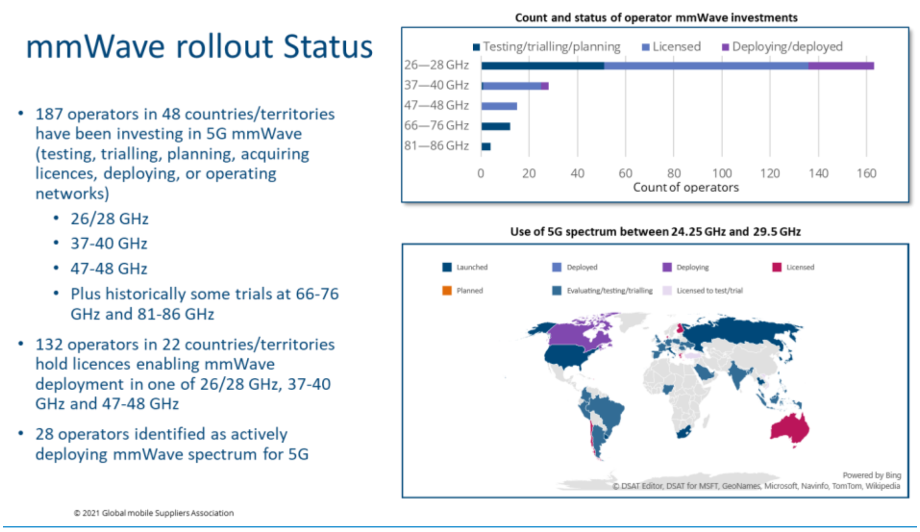
With the completion of the standalone (SA) Release 15 of 5G specifications by 3GPP in June 2018, the 5G System specification has now reached its official stage of completion, and the whole industry is taking the final sprint towards 5G commercialization. Many countries play an important role in guiding the global 5G industrialization actively, and have accelerate the promotion of 5G frequency planning and licensing scheme.

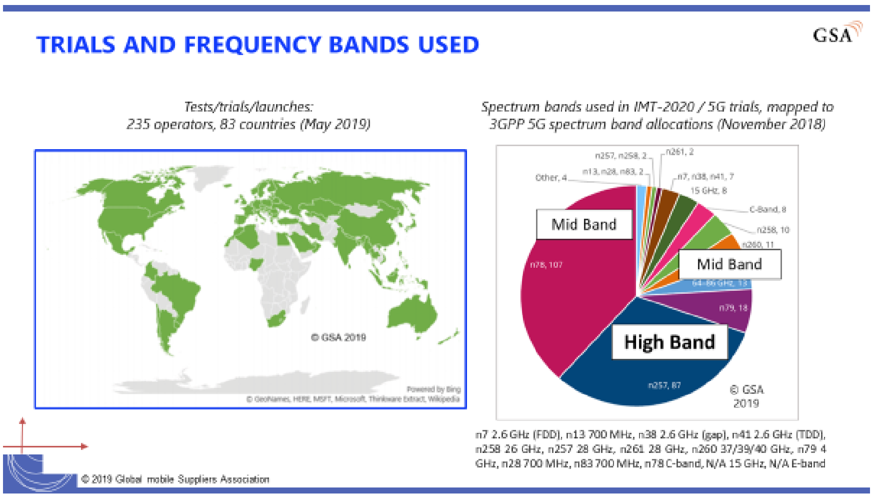
Currently, some administrations focus on multiple 5G core candidate frequency bands, including millimeter-wave bands. Although there are some differences in spectrum status, industry foundation and application scenarios, the following 5G spectrum consensus has been basically formed that the frequency bands below 6GHz will be mainly used to provide continuous coverage, basic capacity and high mobility of 5G systems, and millimeter-wave frequency bands will be mainly used to optimize 5G transmission rate and increase system capacity.

~~*[Propose the following two paragraphs for deletion: The number of trials in which particular bands do not provide any useful information about 5G implementation issues. Moreover, these statistics are mixing bands below 6 GHz and above 24.25 GHz, where the former is not relevant to the scope of this document.]*~~

~~According to statistics from Global mobile Suppliers Association (GSA) there has until May this year been tests/trials/launches by 235 operators in 83 countries (see below in Figure 1). By far the most used bands for these events are the 3GPP band 78 (3300-3800 MHz) and band 257 (26.5-29.5 GHz).~~

According to statistics from Global mobile Suppliers Association (GSA) there has until July this year been tests/trials/launches by 132 operators in 22 countries (see Figure below) in mmWave frequency bands.

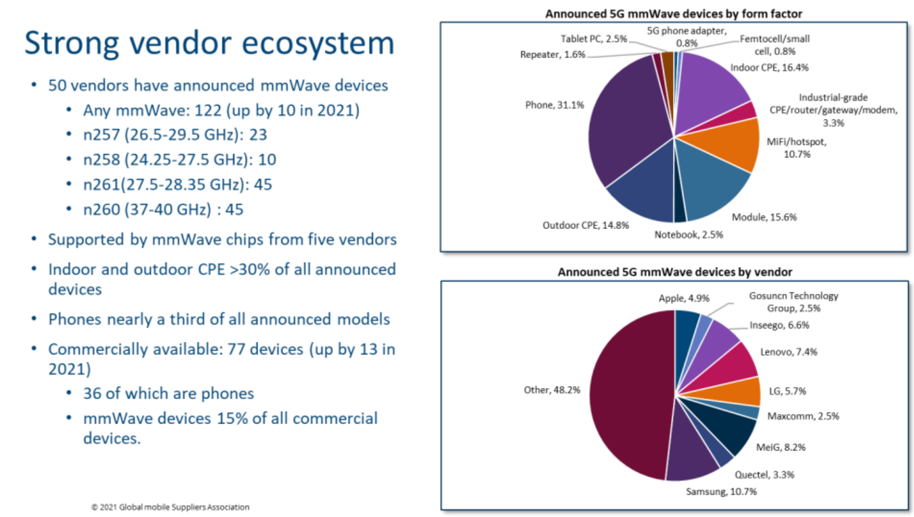




~~Figure 1: Statistics from GSA on trials and frequency bands used~~

~~Up until today, 12 commercial networks have been launched. To be successful in 5G, timely build-up of the ecosystem is needed. The mobile industry sees a clear commitment and increasing 5G focus from chipset and device vendors. The first 5G devices were launched in 2018, and by the end of 2019 over 10 million 5G subscriptions are projected worldwide with more substantial volumes on different bands expected from 2020.~~

To be successful in 5G, timely development and ramping up of the ecosystem is essential. The figure below shows a clear commitment from the chipset and device vendors in the mobile industry towards increasing the vibrant 5G ecosystem in mmWave spectrum.



5.1 China

5G trial progress in China

China has been actively promoting the domestic coordination and R&D of some candidate frequency bands listed in ITU-R Resolution 238 (WRC-15). On June 2017, China issued the spectrum consultation to the public on use of the fifth generation international mobile communication system (5G) in the millimeter-wave band, seeking the opinions on 5G system frequency planning on 26GHz, 40GHz or other millimeter-wave band. On July 2017, China approved 26 GHz and 40GHz frequency bands to be utilized as the spectrum of IMT-2020 R&D trial. Recently, China plans to continue the trial on research and testing the key technologies on 26GHz frequency band and plans to focus on the 5G base station function, RF and performance test in the later stage.

5.2 Republic of Korea

The Republic of Korea has auctioned 5G spectrum including 3.5GHz (3420 – 3700 MHz) and 28GHz (26.5 – 28.9 GHz) in June 2018 and launched world's first 5G services onApril 2019 with 5G smartphones using 3.5GHz. Commercialization of 28GHz is also expected in the end of 2019.

In order to be at the forefront of the global 5G competition, the Republic of Korea completed a auction process in June 2018 for the 3.5 GHz and 28 GHz bands. The Korean government made available a total of 280 megahertz in the 3.5 GHz spectrum band and 2,400 megahertz in the 28 GHz band. The government divided the 3.5 GHz and 28 GHz spectrum into 28 blocks and 24 blocks, respectively. Participant operators SK Telecom, KT, and LG U+ had a 10-block cap per spectrum band. The telcos paid a total of 3.6183 trillion won (US $3.3 B) for the spectrum, 340 billion won higher than the starting price of 3.3 trillion won. The 3.5 GHz band licenses have a ten-year term, and the 28 GHz band licenses have a five-year period.

[Korea Operators 5G Spectrum Auction Result]

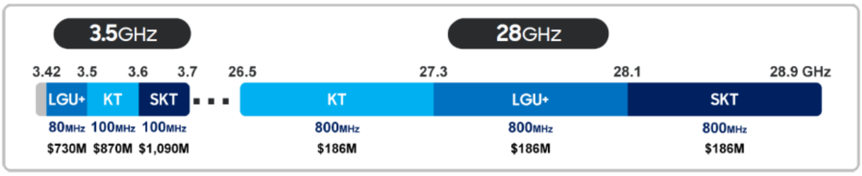


Figure 1: Korea Operators 5G Spectrum Auction Result

…

[The information from other countries]

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6 5G International developments

6.1 ITU-R

The World Radiocommunication Conference 2019 (WRC-19) have identified additional radio-frequency bands for International Mobile Telecommunications (IMT) in the frequency bands 24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz, which will facilitate the development of 5G mobile networks. In addressing the technical compatibility with services also allocated in these frequency bands, WRC-19 concluded on a number of measures as outlined in the *resolves* parts of Resolutions **241 (WRC-19)**, **242 (WRC-19)**, **243 (WRC-19)** and **244 (WRC-19)**, which are mandatory text, since these Resolutions are incorporated by reference in Article **5** of the ITU Radio Regulations (RR). Administrations wishing to implement 5G in these frequency bands are required to comply with these measures, as appropriate.

WRC-19 also took measures to discuss the elements of Article **21** of the ITU Radio Regulations, including the applicability of the conducted power limit in No. **21.5** for terrestrial stations to be deployed with Active Antenna Systems (AAS) in frequency bands above 24.25 GHz. This provision is critical for the protection of the receiving space station.

~~From WRC-19 Document 550 – "ITU-R is invited to study, as a matter of urgency, the applicability of the limit specified in RR No. **21.5** of the Radio Regulations to IMT stations, that use an antenna that consists of an array of active elements, with a view to recommend ways for its possible replacement or revision for such stations, as well as any necessary updates to RR Table 21-2 related to terrestrial and space services sharing frequency bands. Furthermore, the ITU-R is invited to study, as a matter of urgency, verification of RR No. **21.5** regarding the notification of IMT stations that use an antenna that consists of an array of active elements, as appropriate."~~

~~***Figure 1: AAS layout***~~

6.2 5GSpecificationdevelopments in3GPP

[Editor's Note: This chapter provides 5G Specification developments progress in 3GPP in the frequency bands above 24.25 GHz]

3GPP has include new 5G/NR bands in Release 15, which are being defined in the following two frequency ranges (FR) in Table 4.

Frequency range designation	Corresponding frequency range
FR1	410 MHz – 7125 MHz
FR2	24250 MHz – 52600 MHz

Table 4 : Definition of 3GPP frequency range

For the frequency band above 24.25GHz, the operating bands for 5G/NR are defined as n257 to n261 in 3GPP TS 38.104.

NR *operating band*	Uplink (UL) and Downlink (DL) *operating band* BS transmit/receive UE transmit/receive F_{UL_low} – F_{UL_high} F_{DL_low} – F_{DL_high}	Duplex Mode
n257	26500 MHz – 29500 MHz	TDD
n258	24250 MHz – 27500 MHz	TDD
n259	39500 MHz – 43500 MHz	TDD
n260	37000 MHz – 40000 MHz	TDD
n261	27500 MHz – 28350 MHz	TDD

Table 5 : NR operating bands in FR2

7 5G industry developments

[Editor's Note: This chapter provides the industry development of 5G implementation, including 5G products, equipment, RF, terminals and other aspects.]

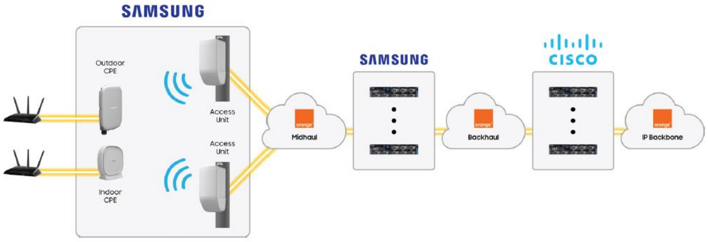
For a full 5G experience and capabilities, spectrum in three frequency ranges are required already in the initial phase; low-bands like 600/700 MHz for wide area coverage and deep indoor penetration, mid-bands like 3300-4200/4400-5000 MHz for capacity and coverage, and then high-bands like 24.25-29.5/37-43.5 GHz for extreme low latency and bitrates.

In Figure 3 below some different characteristics of various deployment scenarios are studied together with frequencies used. The usability depends on deployment and building characteristics, but the interworking between lower bands and high bands are crucial to achieve good coverage and extreme capacity at the same time.

8 5G implementation and Field Trails

- Field Trials in Romania

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.



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.

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.

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

Conclusions

• Customer feedback was overwhelmingly positive, with some users reporting a better experience than on their current fixed broadband services. 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.

- **Field Trails in USA**
- **Field Trails in Europe**
- **Field Trails in Hong Kong**
- **Field Trials in Japan**
- **Field trials in India**
- **Field trials in Korea**
- **Field Trials in London**

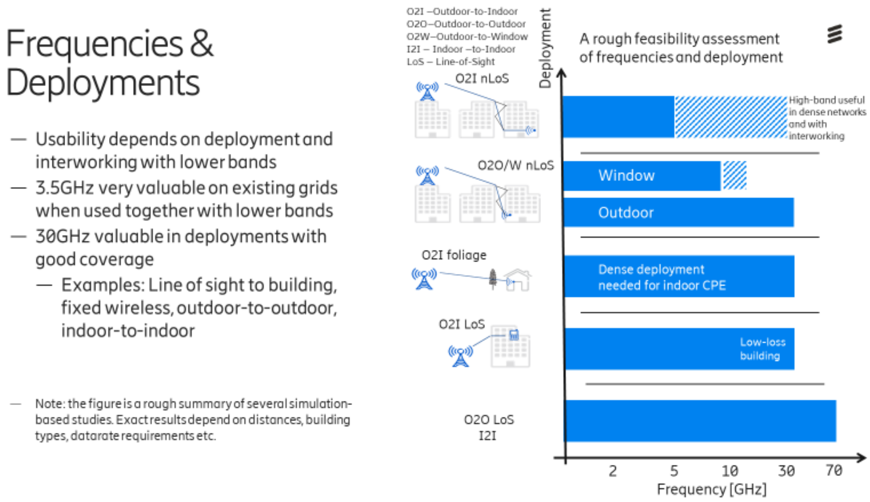


Figure 2 : Summary of several simulation studies on frequencies and deployments

5G at mid and high bands is well suited for deployment at existing site grid, especially when combined with low-band LTE. Adding new frequency bands to existing deployments is a future-proof and cost-efficient way to improve performance and meet the growing needs of mobile broadband subscribers and deliver new 5G-based services.

Thanks to beamforming and antenna technology, the need for site densification is much smaller than anticipated. In Figure 4 below the result of a simulation study of NR in 26 GHz with 200 MHz bandwidth showing the coverage in London while using an existing site density. It shows that there is very good outdoor downlink coverage, but also to some extent indoor coverage in low-loss buildings near sites.

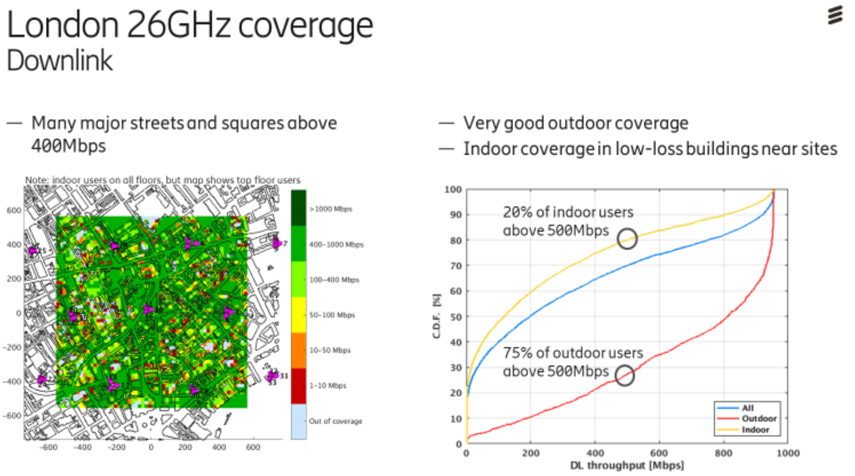


Figure 3: Urban area coverage in 26 GHz downlink with existing site density

Also the uplink coverage is good in outdoor environments in the 26 GHz band using the existing site density in an urban environment especially along major streets and squares as seen in Figure 5 below.

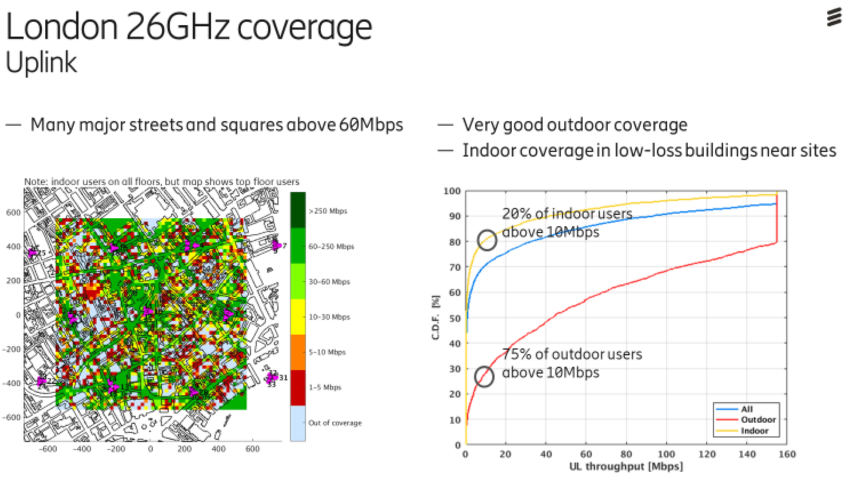


Figure 4 : Urban area coverage in 26 GHz uplink with existing site density

When considering also interworking between LTE and NR and then in various frequency bands the performance is increased. In this study 100 MHz of NR in the 3.5 GHz band was added to the 200 MHz in 26 GHz band, as well as 2x10 MHz of LTE in 800 MHz band and 2x20 MHz LTE in both 1800 and 2600 MHz bands. The result is shown in Figure 6 below for downlink achieving data rates above 1 Gbps in many major streets and squares with indoor coverage. It is important to note that a channel of 200MHz was assumed for these 26 GHz deployment simulations. Increased channel sizes of 400, 800 & 1000MHz will result in significantly increased performance. Some industry associations such as the GSA recommend approximately 1000 MHz of contiguous spectrum per network.

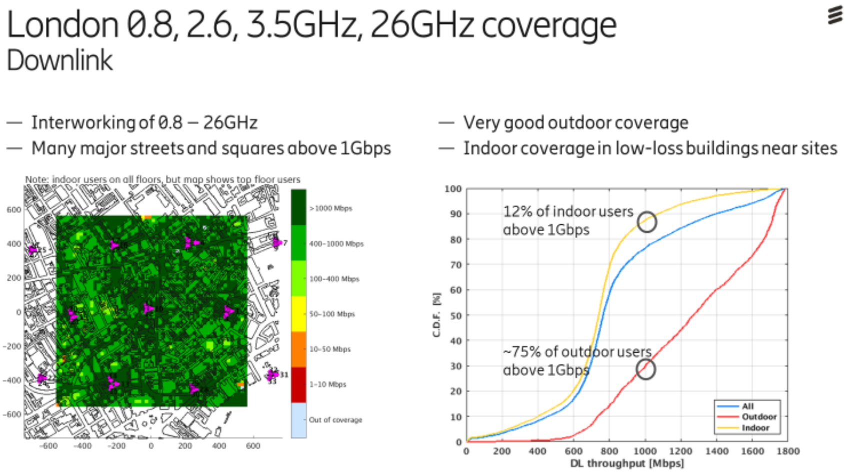


Figure 5: Interworking of LTE+NR downlink in 0.8-26 GHz using existing site density

The corresponding result for uplink is shown in Figure 7 with very good outdoor coverage complemented with low-band indoor coverage.

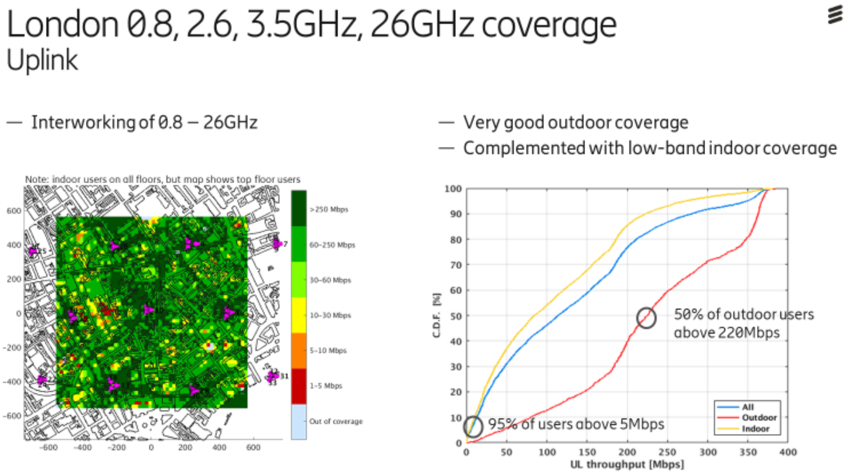


Figure 6: Interworking of LTE+NR in 0.8-26 GHz using existing site density

It is shown above that combining 5G NR with LTE and using a various frequency bands gives a very good wide area performance in urban areas by using the existing site density. Densification is thus not needed from the start when launching 5G but can happen at later stage and may also be difficult in some countries/cities. Additional information can be found in the embedded article below from the Ericsson Technology Review entitled “5G NR with LTE at existing sites”.

Combing 5G NR with LTE.pdf

9 Case studies for 5G implementation in some countries

[Editor's Note: This chapter provides the case studies in those countries that have implemented or plan to implement 5G. It could provide the experience or solutions of solving interference problems (for example, the interference between IMT and other services) when implementing or planning to implement 5G in those countries.]

This section covers the case studies of technical condition adopted by administrations for co-existence of incumbent services and 5G in band above 24.25 GHz.

In band above 24.25GHz, various scenarios were considered for co-existence and technical conditions were expected to be developed. WRC-19 has provided guidance for. some of the technical conditions, in specific, Protect EESS (passive) in 23.6-24 GHz with unwanted emission limit (a2a), and Protect Receiving space stations in ISS and FSS (E-s) with in-band TRP (a2e) in band 24.25-27.5 GHz. WRC-19 has invited ITU-R to submit sharing studies and suggest possible interference mitigation mechanisms for Protect Earth stations in SRS/EESS in 25.25-27 GHz (a2c) and transmitting earth stations in FSS (E-s) at known locations (a2d) tohelp administrations in making them an informed decision about co-existence of incumbent with 5G services. (Please see Resolution 242 WRC-19)

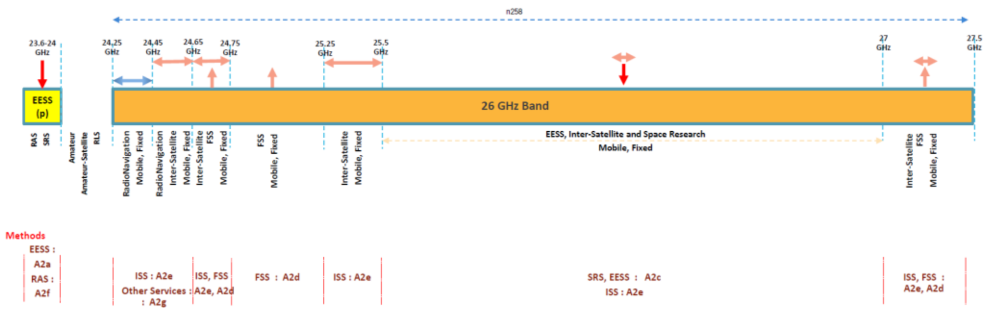


Figure 7: Incumbent services and technical conditions in the band ~~above 24.25~~23.6-27.5 GHz.

Study on Coexistence of 5G with other services

While band between 26.5 to 29.5 GHz has not identified by ITU for IMT services, however this band has identified by ITU for mobile services on primary basis. Countries, especially those who have opted whole band range until 29.5 GHz for 5G services has faced additional challenges due to limited availability of co-existing results. Countries like Japan USA, Korea has conducted 5G specific co-existing study and found possible co-existence of 5G and satellite services in band between 26.5 to 29.5 GHz.

In-band between 24.25 to 29.5 GHz, many co-existence scenarios are possible between 5G and satellite services. The band 27.5-29.5 GHz is allocated globally for FSS (Earth-to-space) and is used by a number of satellite systems – geostationary and non-geostationary. New satellite systems are being deployed in this band. The satellite applications used in this band include gateway earth stations (for example providing feeder links for satellite user links using other band), for small fixed terminals for broadband connectivity and mobile terminals ("Earth stations in motion", ESIM). WRC-19 developed a regulatory framework for ESIM operations in the band 27.5-29.5 GHz and the space-to-Earth band 17.7-19.7 GHz in Resolution **169 (WRC-19)**. ~~however, t~~The below-mentioned co-existence scenarios are considered in this section.

In the earth to space transmission of the satellite services scenario, where, interference from Aeronautical-ESIM (A-ESIM) to 5G services has evaluated. Earth station has considered in motion for A-ESIM.

In the earth to space transmission of the satellite service scenario, aggregated interference 5G stations at the space station receiver is to be evaluated in multiple segments of the band between 24.45 to 27.5 GHz was resolved in WRC-19. This scenario also is equally important for satellite services operating in the band 26.5-29.5 GHz for APT countries considering 5G in this portion of the band.

In the case of the band 24.45-27.5 GHz, ITU-R studies concluded that the aggregate interference from IMT stations to satellite receivers would not exceed the satellite interference criteria, based on certain assumptions regarding 5G systems characteristics and deployment. This led to a number of regulatory provisions to be included in the resolves of Resolution **242 (WRC-19)** related to the deployment of 5G base stations.

The ITU has not studied the use of IMT-2020/5G systems in the band 27.5-29.5 GHz given that this band is not identified for IMT in the Radio Regulations. Hence any use of the band 27.5-29.5 GHz for 5G services requires additional considerations, such as operational constraint for the protection of receiving space stations, as well as for the coexistence with transmitting earth stations in close vicinity.

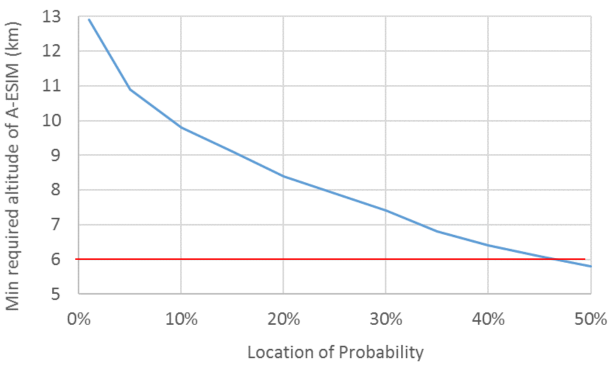
[Editor's Note: In following parts in AWG-26 some concerns are expressed that some paragraph regarding sharing conditions seems a little too conclusive and would make readers confused. In understanding that this is a case study in each country, sentences should be properly revised not to make any global conclusive impression, taking into account studies and discussion in the past and on-going work in WRC and related meetings.]

9.1 Republic of Korea

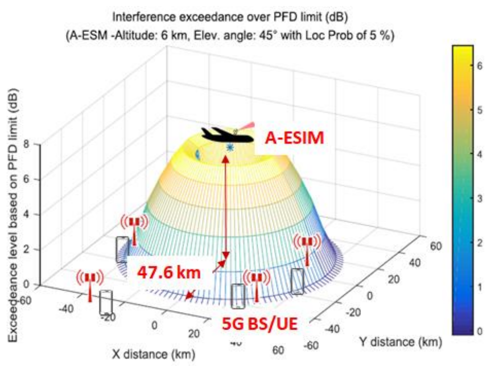
[Editor's Note: Korea provided modified text in AWG-26]

To assist successful 28GHz commercialization, the Republic of Korea conducted the study how to coordinate with other services in 28GHz. 28GHz (27.5 – 29.5 GHz) is identified as global bands for ESIM usages at WRC-19. In the other hands, administrations are getting interested in using 28GHz for 5G services since the 28GHz 5G ecosystem is already available. Therefore, to coordinate between especially Aeronautical-ESIM services and 5G, the Republic of Korea conducted the study to investigate the applicable direction to implement A-ESIM and 5G simultaneously by assessing interference exceedance from A-ESIM to 5G as Mobile services.

The study intends to protect all types of 5G systems which are defined in Recommendation ITU-RM.2134. The study evaluates, in a given altitude of A-ESIM, how much interference exceedance at which location from BS A-ESIM causes to protect all 5G system in 50% and 5% location probability of clutter environment. The study results in the 6km altitude at which A-ESIM does not cause unacceptable interference from-6 dB I/N of all 5G systems based on medium (50%) location probability of clutter environment. It is shown in Figure below



Furthermore, the study results inwithin47.6kmgrounddistancefromA-ESIMwhereBSreceives exceedance interference under 5% location probability of clutter environment. It is shown in Figure below



With those results, as the main purpose of study,6kmofESIMaltitudeis an appropriate altitude above which A-ESIM service could be allowed without any restrictionto5Gservices. It means normally to ensure the protection of terrestrial 5G services from A-ESIM below the altitudeof6km. In addition, It could be also learned that neighboring countries located less than 147.6 km far from an international airport could receive unacceptable interference of A-ESIM with 5% probability of location. It is due to the fact that an international takeoff flight could move at least 100 km[2] at ground level to reach 6 km altitude.

9.2 United States of America

[2]This distance was estimated from www.flightstats.com

[Editor's Note: Concerns were raised about the inclusion of the USA case study that is not a country specific case study relevant to APT region and suggested deletion of this section.]

Satellite operators have raised concerns that aggregated interference originated from mobile service in 28 GHz will cause interference at the satellite space station, which will degrade the performance of satellite operation. Satellite operators have demanded to bring restrictions on the terrestrial base station and UE station transit power. They have further advocated providing secondary status to mobile service in the band between 27.5 to 29.5 GHz.

The mobile industry has presented results and views obtained from the study. The following arguments were put forward for the discussion.

LMDS has co-primary status with satellite services in the band between 27-29.5 and FCC should view fixed link and mobile services with the same specs. LMDS can operate point to point and point to multipoint; as per current regulation, maximum transmit power EIRP for LMDS services is 85 dBm, wherein, maximum EIRP adopted for mobile services in this band is 75 dBm.

The mobile industry has suggested that the model used for evaluation must consider,

- Antenna down tilt of the base station, which is an essential design element in mobile service to maximize data throughput for the serving UEs. The down tilt of the antenna will minimize signal towards the sky.
- Power control at the UE stations i.e. UE transmission power should be derived based on channel experience by UE's. Cell edge UE's likely to transmit with high power compare to cell centre UE's to compensate for the mutual coupling loss between the base station and UE. Moreover, the probability of off-axis direction towards the sky of pairing beam between the base station and UE should be modelled. The primary motivation of power control is to maximize UE battery performance, while maximizing UE data throughput.
- Dynamic nature of beamforming, where beam-pairing between UE and base station direction can change per transmit time interval, moreover direction of base station beam would be towards the UE stations to have optimal beam alignment. Dynamic beamforming is a key component of the mmWave mobile system, which will minimize aggregated interference at other services by dynamic beam paring between the base station and UE.

Conclusion

The satellite industry could neither bring strong argument to show right to protect aggregated interference originated from terrestrial stations nor shared studies based on realistic modelling and assumptions of mm Wave terrestrial system. FCC has ensured to revisit current decisions based on enhanced understanding of mm Wave wireless modelling. [1]

9.3 Japan

[Editor's Note: Japan provided modified text in AWG-26]

In order to investigate a possibility to deploy 5G systems in the frequency band 27.0-29.5 GHz in Japan, sharing and compatibility studies between 5G and incumbent applications mentioned below were conducted.

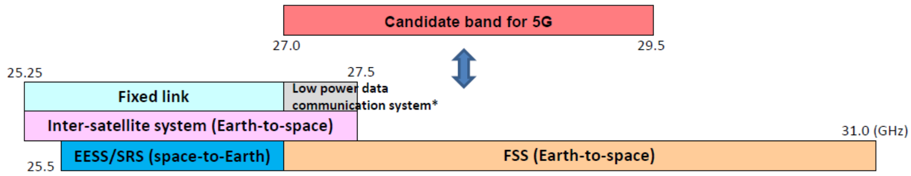


Figure 8: Incumbent applications considered in sharing and compatibility studies in Japan

It could be seen that Japan has the fixed satellite service allocation in Earth-to-space direction in the frequency band between 27 to 31 GHz. Interference originated from 5G stations will be received at the space station and may have some bearing with the operation of the fixed satellite services.

Japan has conducted a study to evaluate the signal received at the space station with the help of simulation, which considers free-space propagation loss, with and without clutter loss based on Recommendation ITU-R P.2108. Japan has considered a specific location of 5G base stations, where those stations are expected to be deployed. In specific, Japan has considered signal originated from 5G base stations within beam view footprint of the space stations for different fixed satellite systems concerned in Japan.

The study from Japan has considered antenna pattern of 5G base station and dynamic beamforming of beam paring between 5G base stations and UEs. "Envelop antenna pattern model" and"Average antenna pattern model" based on the Monte-Carlo simulation was considered in the study with variation due to dynamic beamforming.

From the study in the Earth-to-space scenario and interference from 5G stations to space station has concluded that more than 50,000 base stations for 5G, under the assumptions used in the study, can be deployed within a beam view of the satellite operating in the band between 27-29.5 GHz while meeting the protection criteria of the satellite space station receivers [2][3]. Based on the results of this study, an interference coordination mechanism between terrestrial and satellite operators in Japan has been established in order to protect the satellite space stations.

[Editor's Note: Suggest that more information is provided on the technical assumptions regarding 5G stations, the assumed characteristics of FSS earth stations, and the interference coordination mechanism that is referred to above.]

9.4 Singapore

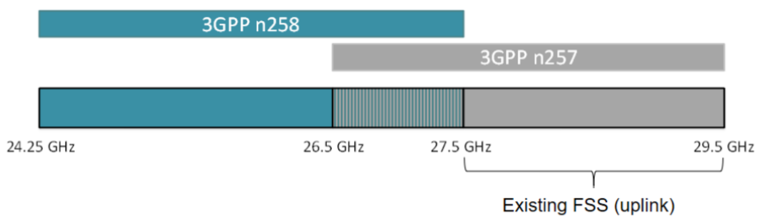


Figure 10: mmWave bands and incumbent services in Singapore

Singapore has noted that number of mmWave bands such as the 26 GHz and 28 GHz (i.e., 24.25 – 27.5 GHz and 27.5 – 29.5 GHz) have been identified for 5G deployment. Many stakeholders have agreed that mmWave bands are important in providing extremely high data rate and capacity, complementing the sub-6 GHz bands that deliver coverage and service continuity. However, as per propagation characteristics of mmWave bands, 5G mobile systems operating in mmWave spectrum will mainly be deployed in hotspots and indoor scenarios.

Singapore has observed that developments in the 28 GHz band had been driven by major mobile markets such as the U.S., South Korea and Japan, and early 5G deployments are taking place in this band. The ecosystem, use-cases and business models developed in the 28 GHz are also estimated to accelerate the development of the other mmWave bands, particularly the 26 GHz band. Wide tuning range spanning across 26 GHz and 28 GHz bands in commercial equipment will benefit mmWave deployment.

Satellite community has drawn the attention towards 28 GHz in specific, where in, 28 GHz band is heavily used worldwide for various satellite services and extensive satellite investments have been incurred in the 28 GHz band. The 28 GHz band is also seen as a critical band for the continued innovation and deployment of the high throughput satellites (“HTS”) and very high throughput satellites (“VHTS”). Satellite community feels that co-channel coexistence between satellite services and 5G networks is generally difficult, and that FS and FSS in neighbouring countries would cause interference to the IMT services deployed in the 28 GHz band in Singapore.

In Singapore, the 28 GHz band is currently used for FSS (uplink), and specifically transmission from maritime vessels to the satellites, to provide on-board broadband connectivity. Singapore recognises that coexistence between IMT and FSS services could be made possible through coordination of the technical parameters and usage in this band.

In future, it is also expected that there will be additional satellite deployments in the 28 GHz band for aircraft platforms. However, since satellite operations are confined to air and space platforms or Earth station in motion(ESIM), Singapore is of the view that coexistence between these satellite service and 5G is possible. If necessary, IMDA will put in place operational guidelines within the licensing condition for satellite services to mitigate interference issues. For example, the minimum distance away from shore and stage of flight for these platforms to transit from terrestrial to satellite services. With the exception of satellite services, there are no indications from the industry of any future planned local deployments in this band.

After taking a comprehensive view on global developments related to the use of the 26 GHz and 28 GHz bands for 5G services, IMDA has decided to allocate these bands on a primary basis to mobile service, in addition to existing allocations, if any. Under this arrangement, mobile service and fixed satellite service operating in the frequency band 28.5 – 29.5 GHz will be on a co-primary basis. Stations in the FSS are expected to take measures to ensure protection of, and not impose undue constraints on, 5G services operating in the band, such as coordinating with MNOs holding spectrum rights in the same frequency band. [5]

Conclusion

Singapore made an observation that 26 and 28 GHz are important bands for 5G, which offers extreme high capacity. While Singapore has incumbent FSS uplink service in this band, Singapore is of the view that, it’s possible to have co-existence with FSS uplink services and ESIM services in 28 GHz band through coordination of the technical parameters and usage in this band. In addition, Singapore also thinks that FSS uplink services should not constraints 5G services, since, mobile service and fixed satellite service should operate in the frequency band 28.5 – 29.5 GHz on a co-primary basis.

[Editor's Note: Placeholders for other APT countries. AWG would invite APT countries to share their experience in IMT-2020/5G implementation in bands above 24.25 GHz that are identified for IMT.]

9.5 Observation

[Editor's Note: Concerns were raised about the inclusion of this section 8.4 that may be too conclusive and would make readers confused. If retained, this section should be reviewed when the preceding sections are stable.]

This section has captured case studies from USA, Japan and Singapore and found similarities with respect to interference scenario, deployment, arguments, studies and conclusions in the band between 27-29.5 GHz. Those countries have recognized that the realistic modeling of mmWave 5G with key design component such as dynamic beamforming, power control are indispensable to evaluate the interference originated from 5G base station to satellite stations in earth to space scenario and space to earth scenario. Studies conducted by the USA,Japan and Singapore show that co-existence between 5G services and satellite services in band between 27-29.5 GHz is possible. It is also noted that 5G could be explored in extended modelling to minimize the interference by virtue of its operation.

Korea has highlighted the co-existence challenges of 5G system with A-ESIM. The study result shows that A-ESIM operation should be restricted below 6 km altitude for 5G to operate in non-interfering manner.

With such trend, a new study on how to deploy 5G systems in mmWave bands taking into account the allocations and operations of systems in other services will be helpful. Such study could include technical and/or regulatory conditions for the coexistence of 5G systems with other services. AWG is the right place to conduct such study which would assist APT member countries to make decisions on 5G deployment in mmWave bands.

10 Summary

[TBD]

11 References

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[5] IMDA: Second-Public-Consultation-on-5G-Mobile-Services-and-Networks/Second-5G-Public-Consultation-7-May-2019