July. 7th, 2017

Response to the public consultation on 5G mobile services and network in Singapore

COMMENTS OF GTI

The Global TD-LTE Initiative (GTI) is pleased to be able to respond to IMDA's consultation on 5G mobile services and networks. This response has been prepared by the Spectrum Working Group of GTI.

GTI (Global TD-LTE Initiative) is an open platform in 2011, advocating cooperation among global operators and vendors to energize the creation of a world-class and a growth-focused business environment. GTI aims to make TD-LTE a global standard and the convergence of TDD/FDD, help the whole industry benefit from the evolution of TD-LTE, TDD/FDD converged networks and global smartphones, and promote a unified 5G standard and mature end-to-end ecosystem, as well as explore cross-industry markets and opportunities. With 6 years' development, GTI has become one of the most important cooperation platforms with 132 operator members and 144 vendors.

Accordingly, we welcome the initiative by the Singapore to review the public consultation for 5G spectrum, mobile services and networks. GTI hereby submits its comments in response to the Singapore's consultation on 5G mobile services and networks.

For any further question, please feel free to contact with us.

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Feedback for the consultation questions

With regards to the consultation questions of the issues for 5G technology and use cases, 1-6GHz and above 6GHz frequency bands, and future spectrum estimation, we would like to explain the views and comments on several aspects as below.

5G Technology and Use Cases

. 1) IMDA would like to seek views and comments on the estimated timeline for the deployment of 5G. Besides ensuring that spectrum is made available in a timely manner, what other regulatory measures could assist in facilitating the deployment of 5G technology and applications? What other use cases should IMDA take note of when developing the regulatory framework?

The GTI companies started 5G study since last year, many projects and tasks were established for study the 5G business model, use case and applications. The GTI industry companies supports the view that a number of application areas will emerge and develop in ways that will put significant strain on current cellular networks e.g. mobile video, smart city and industrial IoT, mobile connected vehicles, cloud-robot, mobile virtual, augmented and mixed reality(VR/AR/MR) and mobile e-health etc. Those applications in terms of number of connected devices, latency requirements and traffic will significant impact to the future spectrum development and characteristics. The text briefly describes the applications.

Enhanced mobile broadband, video, and consumer virtual, augmented and mixed reality services

The consumer market for mobile broadband continues to grow at a very fast rate – in terms of the number of users connected to mobile broadband networks and the volume of data those users are downloading and uploading. By 2020, the total mobile data traffic is expected to grow about 10 times[1] compared to current levels of mobile data traffic, and mobile broadband networks will also be supporting about 9 billion mobile subscriptions[2]. In some markets, mobile broadband will be the only broadband.
To the well-established trend of increasing volume and resolution of video content using mobile broadband can be added the expectation of virtual, augmented and mixed-reality (VR, AR and MR) content. Future mobile devices will wearable glasses and headsets as well as smartphones, delivering a more immersive experience than is available today. Once suitable devices are in the hands of sufficient users – and this process is expected to be fast – the network effect will kick in and private and public-sector organizations will start to take advantage of the communications medium of VR.

Vehicles and transportation

Vehicle connectivity is increasing very fast, and the types of applications for connected vehicles range very widely, from condition monitoring involving low-bit-rate and infrequent connection with vehicle manufacturers or other central facilities, through driving monitoring for insurance purposes, and download of video entertainment and information services for passengers, to low-latency vehicle-to-vehicle and vehicle-to-infrastructure connections for autonomous driving and safety purposes. Public transportation and vehicle fleets are increasingly integrated into broader systems too, and electric vehicles and their charging infrastructure will become increasingly prevalent.

Industrial automation

Improvements in robotic systems, the development of artificial intelligence, and the collection and use of big data are changing the ways in which factories are designed and operated. Alongside development of new manufacturing techniques such as 3D printing and use of novel materials, the manufacturing sector is making use of communications technologies to enable a transition to “Factory 4.0” or “Industry 4.0” visions where the entire supply chain is connected and automated – from the design of new products and the supply of raw materials to the maintenance of finished products in consumers’ homes or business customer premises. Within the factory itself, higher levels of automation are enabled with autonomous robots and machine learning continuously optimizing processes. Beyond the factory, in extractive industries, networked drones will revolutionise site surveys and help enable greater automation through mapping and real-time terrain monitoring and analysis.

Mobile health

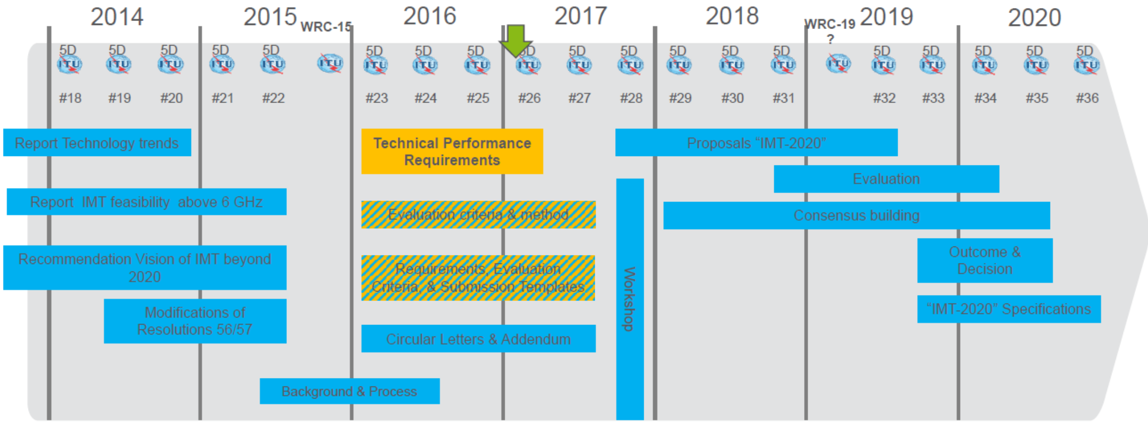
Telehealth services including remote diagnostics, remote monitoring, automation of care in the home, the integration of personal fitness wearables into broader healthcare systems, and remote surgery and training, will all require or benefit hugely from the reach and capacity of future wireless networks. In particular, the extension of the healthcare environment beyond specialist settings (such as hospitals and care homes) to include individuals’ home and people going about their daily lives wherever they are, is primed to have a transformative impact on how patients are monitored and looked after.

Smart cities

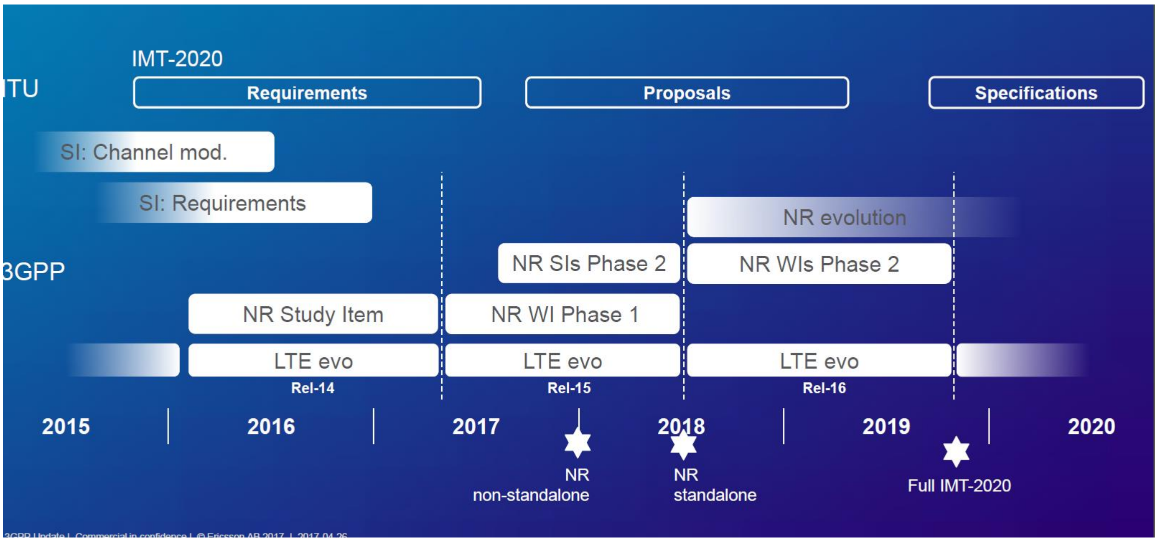
Not a single class of applications, but rather a catalysing environment for multiple applications, smart cities will themselves be drivers of wireless networks in the coming years. As the world’s population becomes increasingly urbanized and city authorities endeavour to make their cities sustainable and attractive, the concepts of integrated local and regional services, opened up to citizens and third parties online, and leveraging new technologies in areas from street lighting and utilities management to transportation to building automation, will become increasingly demanding of wide-area communications technologies.

All these types of applications require both timely and sufficient spectrum support and also other regulatory framework like security.

The overall timeline from ITU and 3GPP outlined in the following figures:



According to the ITU IMT-2020, 5G technical performance requirement and evaluation method and configuration have been finalized in June 2017. The submission of 5G technology will be started from October 2017 from different regions for the basic 5G concept technologies and complete submission will be finalized in June 2019. The ITU IMT-2020 evaluation process will be started in H2 of 2018 and finalized in March 2020 and full IMT-2020 specifications will be included in the ITU-R recommendation for different regions and administrations' endorsement. And 2020 year would be the commercial time frame for many countries.



3GPP has agreed to the accelerated time schedule for 5G standardization. It will be an early drop version called NR phase 1, before Rel-15 by the end of 2017 for Non-Standalone 5G NR without new core network, it will target for eMBB and URLLC (adding reliability and low latency). NR phase 2 will be finalized by June 2018 to include Standalone 5G NR deployment. Rel-16 will support full IMT-2020 specification and finalized by the end of 2019.

Different countries have their plan to start the 5G deployment.

- Japan and Korea may start the allocation process in 2018 in order to launch commercial 5G service in 2020.
- China government announced their 5G commercial deployment plan in 2020
- European Commission released the 5G Action Plan, targeting early network introduction by 2018, and moving towards commercial large-scale introduction by the end of 2020 at the latest.
- The U.S. operators are pushing launch 5G services as early as possible

So, from the point of view on global 5G development progress, the initial 5G deployment may start from 2020 and the spectrum allocation process would be expected in 2018.

. 2) To facilitate and understand potential spectrum requirements for IoT deployments in Singapore, IMDA would like to seek views on the following: i) Based on the current spectrum allocated for mobile services in the sub-1 GHz frequency bands, are there further suitable spectrum resources that could be released to support both IoT and LTE services? ii) How will future generations of mobile networks (e.g. high capacity, low latency) support the growth of IoT and what would be the spectrum requirements?

GTI companies support the opinion that 5G will need to be deployed also in bands already harmonized below 1 GHz, including particularly the 700 MHz band, 800MHz and 900MHz, in order to enable nationwide and indoor 5G coverage and support IoT type of application and also support the IoT in-band applications for the existing 2G/3G/4G band in 1800MHz and 2100MHz etc. For V2X spectrum, a global harmonized spectrum in 5850-5925MHz is gradually adopted in different regions.

. 3) IMDA would like to seek views and comments from industry on what they consider will be the key technologies for 5G and whether current regulatory frameworks sufficiently facilitate the deployment of such technologies.

3D-MIMO is definitely a 5G representative technology. What's more, 3GPP has been developed 5G NR since 2016, new radio technologies will be introduced to support flexible scalable frame structure design to cover different spectrum from low to high frequency and support different bandwidth to support different application and vertical services. It will also introduce new way of spectrum using, both un-licensed spectrum and shared spectrum using.

<u>1 – 6 GHz Frequency Bands</u>

. 7) If it is only the extended C-band that is considered for IMT, would the migration of existing satellite users to the other parts of the C-band (i.e. 3.7-4.2 GHz) impact their service provisioning?

GTI's view is that there will not be major impact to the provisioning of satellite services. On one hand, the similarity of propagation condition in extended C-band and C-band makes the migration technically feasible. Considering the user applications and the utilization of the extended C-band, we believe the social and economic impacts of the possible migration is also acceptable. We would like to note that the extended C-band is becoming a global band for IMT, and in many regions/countries like China, EU, US, Japan and Korea, regulators are already taking actions or considering taking actions to clear the band for IMT, even the band is used for provision of satellite services. Also, to be noted is the trend from satellite industry itself to migrate the services to higher frequency bands, such as Ka and Ku band.

. 8) Considering the challenges of co-channel deployment of FSS and IMT services in the extended C-band, IMDA would like to seek views and comments on the coexistence measures for adjacent bands and cross border operations.

GTI believes there are many measures to enable the adjacent channel coexistence between IMT and FSS.

Firstly, reasonable RF requirements should be applied at both IMT and FSS sides. Secondly, close coordination between IMT and satellite operators needs to be established, and information e.g. on the geographical locations of the sites, can be exchanged.

Thirdly, from IMT side, there are many techniques which can help to limit the interference to FSS, e.g. multi-antenna beamforming, antenna tilt adjustment and antenna backplane screening.

Finally, some site solutions can be employed, e.g. FSS site screening or smart selection of IMT site locations. We believe similar measures, if appropriate, can also apply for cross-border operations, and we would like to note that given the global harmonization of extended C-band as IMT band, the need/efforts for cross-border coordination will diminish.

. 9) IMDA would like to seek views and comments on whether there are other frequency bands in the 1-6 GHz frequency band that IMDA should consider for IMT / 5G.

GTI would suggest IMDA to also consider the frequency range 4.4-5GHz, whichever part appropriate for Singapore. This range is also a potential candidate for IMT/5G in some regions/countries like China and Japan.

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Above 6 GHz Frequency Bands

. 10) IMDA would like to seek your views and comments on the following:

i) The role mmWave bands will play in delivering the vision of 5G, in particular, what services could not be delivered by alternative frequency bands and / or technologies;

ii) The amount of spectrum required in the mmWave spectrum bands to meet 5G applications that will require higher bandwidths; and

iii) The specific mmWave bands that you consider should be a priority in Singapore for IMT services and why?

ITU-R has identified 3 major usage scenarios for IMT-2020/5G (Fig. 1). Bands below 6 GHz are of high value and recognized as “key” bands for 5G in its providing the majority of 5G use cases and applications.

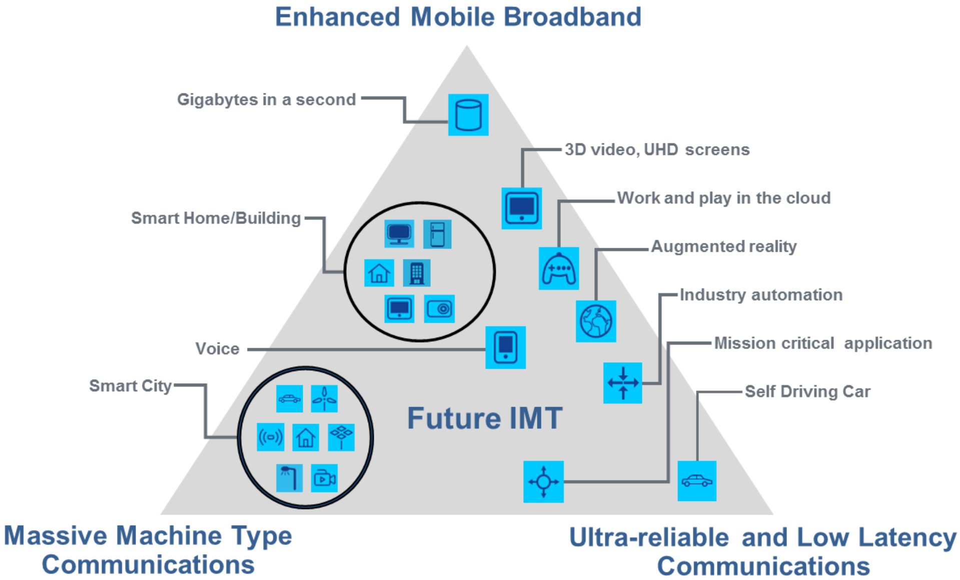

Fig 1. 5G key senarios

The mmWave bands are considered as complementary to the current “key” IMT bands below 6 GHz for providing extremely high data rates required for the enhanced MBB services (eMBB), e.g. 10-20Gbps peak data rate and 1Gbps user experienced data rate, with its potential large bandwidth. For the eMBB case, given the limited propagation capabilities of mmWave, the mmWave will be mainly deployed in hotspot and indoor, and it cannot be standalone and the hetnet architecture is necessary in which below 6GHz for coverage/service continuity or medium capacity while mmWave provide capacity offloading. mmWave bands will also provide WTTx (Wireless To The x) services via large bandwidth to offer a “fiber-like” broadband access, which is identified as one of four major 5G business pillars as in Figure 2.

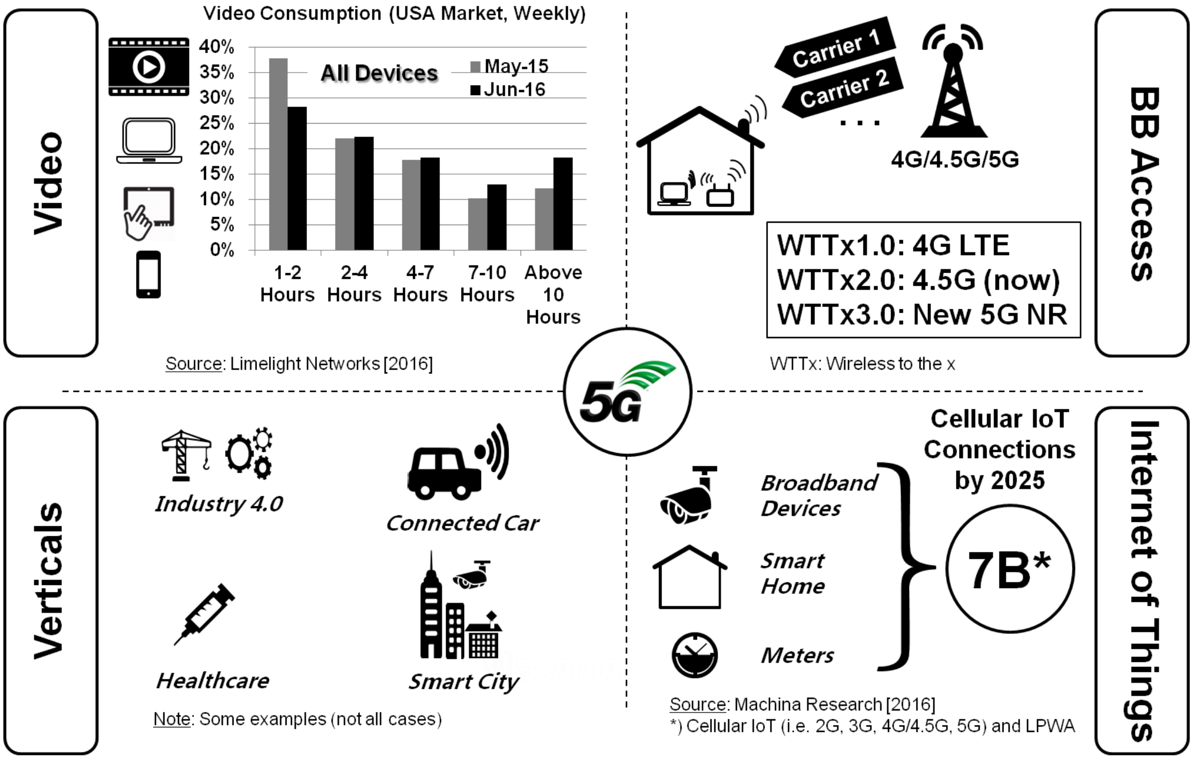

Fig 2. Use case of 5G

ii) The amount of spectrum required in the mmWave spectrum bands to meet 5G applications that will require higher bandwidths; and

The amount of 800 MHz – 1 GHz continuous bandwidth per MNO on the frequency 24.25-27.5GHz is preferable for mmWave initial deployment. Large bandwidth is the only merit of mmWave bands compared with bands below 6GHz, which could compensate its shortage on propagation. Within 3GPP, the maximum bandwidth per mmWave carrier is 400MHz, and the average throughput of 400MHz@26GHz is comparable with 100MHz@C-band, but the coverage of mmWave deployment is challenging especially for the outdoor to indoor coverage, not to say the transmission reliability given that mmWave is easily blocked by leaves, human bodies and etc. From this perspective, 400-500MHz continuous spectrum per MNO at initial phase is necessary to present the value of mmWave bands and then MNOs may have interest to invest. And allotting 800MHz – 1GHz continuous bandwidth to one MNO together will save the design complexity and cost compared two seperate 400-500MHz.

iii) The specific mmWave bands that you consider should be a priority in Singapore for IMT services and why?

24.25-27.5GHz and 37-43.5GHz should be considered as high priority bands. Because the eco-system for these two bands is being developed, and early deployment will be before year 2020. These two bands are within WRC-19 AI 1.13, and global harmonization can be expected.

. 11) Considering that there are 11 candidate bands under consideration at WRC-19, how would making available the 28 GHz band help in the deployment of 5G services in Singapore? Would this band play a significant role in achieving the targets set out for 5G (i.e. higher throughput, ultra-low latency)?

The development of 28GHz is pilot for the mmWave business. 28GHz will be the earliest commercialized band, and the eco-system is being developed now to provide the early deployments before and around 2020 as driven by the USA, KOR and JPN markets. The eco-system, use cases and business models developed for 28GHz will accelerate the development of the other mmWave bands, especially the adjacent 26GHz. From year 2018, Europe and China will also consider trials and commercialization on 26GHz. It's expected the eco-system of 28GHz and 26GHz as the same around year 2020. Given that Singapore considers to start mmWave deployment after year 2020 and It's suggested Singapore choose the mmWave bands of regional and global harmonization.

. 12) If the 28 GHz band is opened for IMT services in Singapore, would there be any future competing services that may be deployed in this band which may cause interference issues?

No comment from GTI, and it depends on the incumbents to provide information.

Future Spectrum Estimation

. 13) IMDA seeks views and comments on the estimated spectrum demand of 3360 MHz by 2025 and whether this estimate is realistic?

As for the spectrum requirement, the spectrum requirements include >6GHz and <6GHz spectrum. And the requirements depend on the services in different countries and regions. The following two tables are founded from the ITU report [3]:

TABLE 13-1

Spectrum needs estimate result of IMT-2020 for both below 6 GHz and above 6 GHz

Deployment scenario	Macro	Micro	Indoor hotspot
Total spectrum needs for below 6 GHz	808-1078 MHz*	–	–
Total spectrum needs for 24.25-86 GHz	–	14.8-19.7 GHz*	
Spectrum needs for 24.25-43.5 GHz**	–	5.8-7.7 GHz	9-12 GHz
Spectrum needs for 45.5-86 GHz**	–	–	

* Considering the coexistence between multiple network operators (e.g. the guard band(s) may be required in the case of multiple network operators' scenarios), the total spectrum needs are expected to be increased.

** The division in this table regarding frequency ranges and deployment scenarios is just an indicative example how spectrum needs could be distributed for different spectrum sub-ranges within 24.25-86 GHz and different deployment scenarios. This table should not be understood nor used to exclude any possible IMT-2020 deployment options in these sub-ranges.

For the spectrum needs of IMT-2020 in the range of 24.25 and 86 GHz, different channel propagation characteristics and available channel bandwidth should be taken into account. With a view to accommodating the wide range of usage and deployment scenarios for IMT-2020, it is important to consider different frequencies within the range 24.25 and 86 GHz. The following tables summary the spectrum needs from some countries and regions.

TABLE 13-2

Spectrum needs for frequency ranges between 24.25 and 86 GHz[3]

	Examples	Associated conditions for different examples (For details, please see the corresponding sections in the Annex A)	Spectrum needs in total (GHz)	Spectrum needs (GHz) per range
Application-based approach	1	Overcrowded, Dense urban and Urban areas	18.7	3.3 (24.25-33.4 GHz range) 6.1 (37-52.6 GHz range)

	Examples	Associated conditions for different examples (For details, please see the corresponding sections in the Annex A)	Spectrum needs in total (GHz)	Spectrum needs (GHz) per range
				9.3 (66-86 GHz range)
		Dense urban and Urban areas	11.4	2.0 (24.25-33.4 GHz range) 3.7 (37-52.6 GHz range) 5.7 (66-86 GHz range)
	2	Highly crowded area	3.7	0.67 (24.25-33.4 GHz range) 1.2 (37-52.6 GHz range) 1.9 (66-86 GHz range)
		Crowded area	1.8	0.33 (24.25-33.4 GHz range) 0.61 (37-52.6 GHz range) 0.93 (66-86 GHz range)
Technical performance-based approach (Type 1)	1	User experienced data rate of 1 Gbit/s with *N* simultaneously served users/devices at the cell-edge, e.g., Indoor	3.33 (*N*=1), 6.67 (*N*=2), 13.33 (*N*=4)	Not available
		User experienced data rate of 100 Mbits/s with *N* simultaneously served users/devices at the cell-edge, for wide area coverage	0.67 (*N*=1), 1.32 (*N*=2), 2.64 (*N*=4)	Not available
	2	eMBB Dense Urban	0.83-4.17	Not available
		eMBB Indoor Hotspot	3-15	Not available
	3	With a file transfer of 10 Mbits by a single user at cell-edge in 1 msec	33.33 GHz (one direction)	Not available
		With a file transfer of 1 Mbit by a single user at cell-edge in 1 msec	3.33 GHz (one direction)	
		With a file transfer of 0.1 Mbits by a single user at cell-edge in 1 msec	333 MHz (one direction)	

	Examples	Associated conditions for different examples (For details, please see the corresponding sections in the Annex A)	Spectrum needs in total (GHz)	Spectrum needs (GHz) per range
Technical performance-based approach (Type 2)	–	Dense urban micro	14.8-19.7	5.8-7.7 (24.25-43.5 GHz range)
		Indoor hotspot		9-12 (24.25-43.5GHz and 45.5-86 GHz range)
Information from some countries based on their national considerations	–	–	7-16	2-6 (24.25-43.5 GHz range) 5-10 (43.5-86 GHz range)

Reference

. [1] Ericsson Mobility report:
http://gsacom.com/paper/ericsson-mobility-report-mwc-2016-edition

. [2] Ericsson Mobility report:
http://gsacom.com/paper/ericsson-mobility-report-mwc-2016-edition

. [3] R15-TG5.1-C-0036!!MSW-E