AI 1.2
Sufficient mobile spectrum for IMT in 3.4-3.6 GHz for CTU

1 Heavy use of the band above 3.6 GHz by FSS

a) *Historic use of the C-band spectrum for receiving satellite earth station (3.6-4.2 GHz)*

The 3.4-4.2 GHz (space-to-Earth) paired with 5.925-6.425 GHz (Earth-to-space) has historically been used for satellite operations for the past 40 years or so. Even today some services still exist in the bands below 3.6 GHz but those do not represent the majority. With time and with the increased interest in other services in the band (such as mobile and fixed), most of the existing services in the band have been pushed to frequencies above 3.6 GHz. This historical context explains why the FSS Earth station receivers are equipped with LNB (Low Noise Block downconverters) capable of receiving in the entire 3.4-4.2 GHz band.

b) *C-band spectrum providing essential capacity for core satellite services*

C-band spectrum is unmatched for comprehensive, wide area coverage via hemispherical and global coverage beams, which are possible thanks to the specific favorable characteristics of the band. The wide area coverage simplifies the ground infrastructure required to provide connectivity between remote points and contributes to lowering the total cost of ownership of a telecommunications solution, compared to an equal-reach terrestrial microwave network.

Video services are a natural beneficiary of wide coverage beams: using hemispherical and global beams it is easy to reach millions of viewers. Other sectors, such as enterprise, government, and defense benefit equally from this feature.

The unparalleled capabilities offered by this frequency range in terms of resilience to service disruptions due to intense rain makes it fundamental for high-reliability services with constant throughput requirements, especially in equatorial and tropical regions where CTU administrations are located. C-band satellite services remain an important connectivity solution for Caribbean administrations which are comprised of hard-to-reach areas and island formations.

c) *Existing services in 3.6-4.2 GHz which require protection.*

We understand that it is at the core of a Regulator’s activities to present and implement a forward-looking spectrum allocation policy, whilst maintaining a balanced approach that recognizes the importance of each telecommunication technology in the overall telecommunications solutions ecosystem. We would like to draw attention to the fact that all services are important component of the end-to-end connectivity solutions in the region : Fixed Service links support Mobile base station deployment, and Fixed Satellite Service solutions act both as elements to enable last mile access as well as integral component of the transmission networks supporting Mobile networks (e.g. backhaul solutions[1]): mobile operators integrate C-band satellite solutions to broaden the reach of their mobile networks. We reiterate that impacting the satellite service allocations in the 3.6GHz to 4.2GHz range will result in reducing the effectiveness of deployment of any eventual 4G/5G infrastructure. The following diagram presents the current split of

[1] https://www.ses.com/case-study/tusass

Intelsat's space-to-Earth capacity for FSS in the C-band, in the Latin America and Caribbean region following 3 categories: 3.6-3.8 GHz, 3.8-4.0 GHz and 4.0-4.2 GHz.

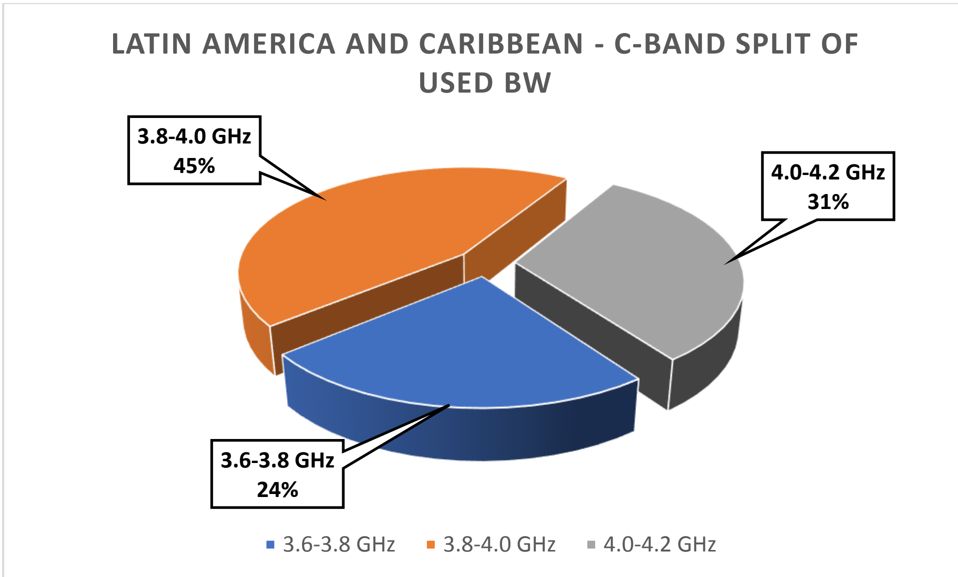

Figure 1. Overview of the FSS C-band capacity use split in frequency

The above diagram shows that the 3.6-3.8 GHz band in Latin America and the Caribbean region amounts to a quarter of Intelsat's C-band satellite usage. This 3.6-3.8 GHz band remains a core asset for satellite capacity in the region with usage that is almost as important as in the 4-4.2 GHz band.

d) Summary of coexistence between FSS and MS

With the increasing demand for C-band mobile spectrum, the major issue lies in the difficulty of coexistence between FSS and MS. WRC-23 AI 1.2 is not the first AI to look at the 3.6-3.8 GHz band for the mobile service with an aim to identifying the band to IMT and sharing between the FSS and MS has been extensively studied. At the International level (ITU-R), studies contained in ITU-R reports M.2109 (WRC-07) and S.2368 (WRC-15) have concluded that co-frequency sharing between FSS and MS is not feasible unless large separation distances (tens to hundreds of kms) are observed to mitigate incoming interference from mobile deployments. Other studies, developed independently by regulators, industry bodies and research groups, have also presented similar conclusions[2]. Establishing exclusion zones to respect these important separation distances can only be achieved if the Earth station location is known. For receive only earth stations that are license-exempt, and for which a precise location is not available, sharing is therefore not possible. This co-existence issue is a fact well-known by administrations wishing to implement mobile deployment in co-frequency mode and often results in the FSS being purged from that same band. In addition, sharing between services in adjacent bands is also a complex issue. The high-power emissions from Mobile service deployments can cause significant impact on the sensitive FSS satellite receivers in the adjacent band. The following figure represents the different interference mechanisms that need to be considered in the adjacent band case:

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[2] See https://www.lstelcom.com/fileadmin/content/lst/marketing/brochures/C-band_compatibility_report.pdf

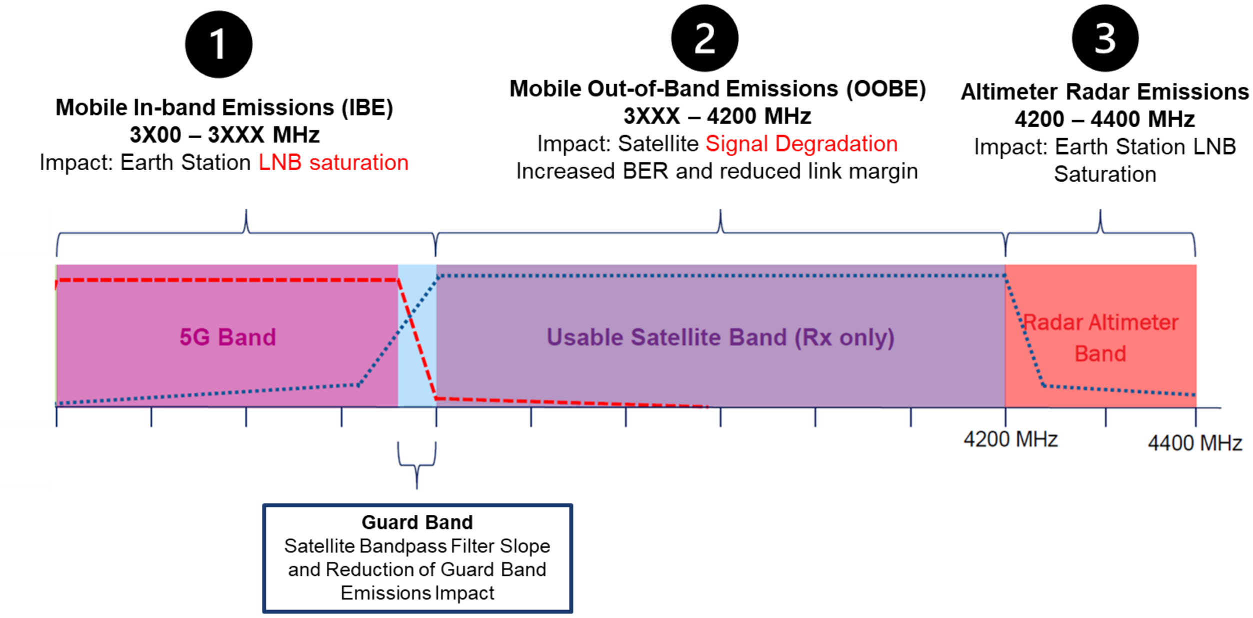

Figure 2. Overview of adjacent band interference mechanisms

❶ As mentioned previously, the FSS earth station receivers have historically been designed to receive in the 3.4-4.2 GHz band. To avoid interference from mobile IBE, the FSS earth stations will have to be equipped with filters. These filters require a certain frequency separation to guarantee a minimum attenuation of the mobile IBE.

❷ The mobile service OOBE can cause significant signal degradation in the FSS earth station receivers. This interference mechanism cannot be filtered out. Good mobile OOBE limits in combination with exclusion zones and frequency separation between the two service will help mitigate this impact.

❸ The issue of mobile OOBE interference into radar altimeters is also a under study today. Several countries have imposed exclusion zones around airports as some risks of interference may exist depending on the amount of frequency separation between the two services.

The figure below provides a summary of the main techniques used to facilitate coexistence of the IMT/Mobile service with the Fixed Satellite Service

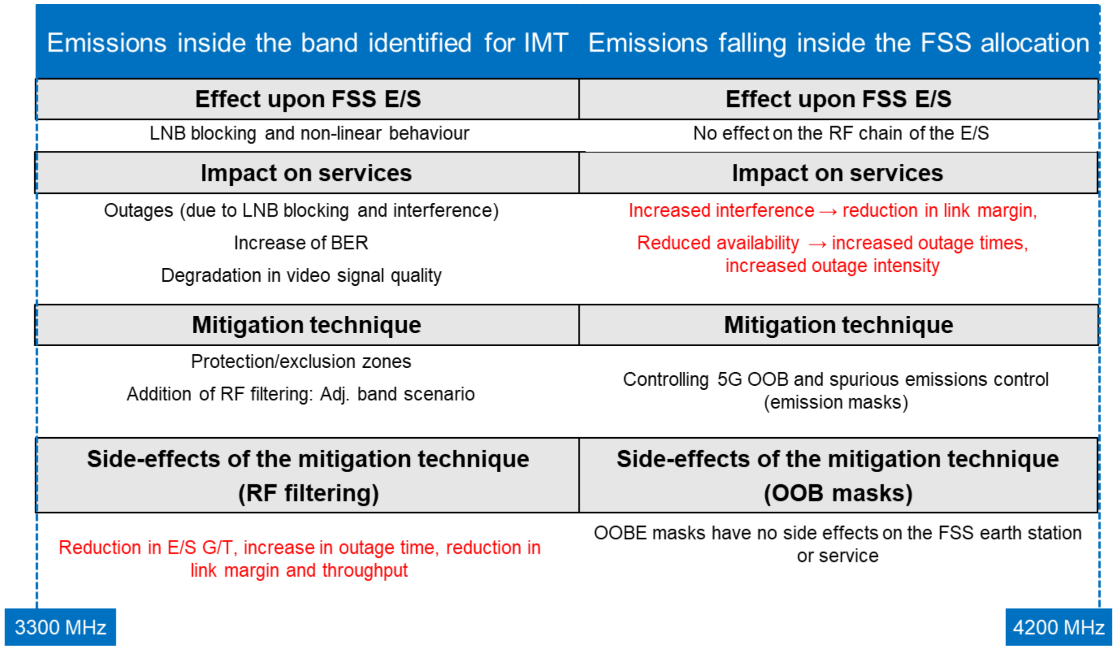

Figure 3 An overview of mitigation techniques applicable to the sharing between IMT/Mobile and FSS

2 The need for mobile spectrum

a) Increasing demand of mobile spectrum, but considering that there are a number of bands available today

We recognize that demand for mobile data is rising rapidly, and that requirements for spectrum may change over time. Mobile operators and manufacturers are constantly pushing for additional spectrum to meet this increasing demand. Nevertheless, it is also necessary to consider the national requirements and market dimension, and the potential of the business case for each Network Operator when spectrum analysis and allocations are made. In the specific case of Latin America and the Caribbean, Mobile operators recognize that 4G deployments need to continue before focus can shift to investments in 5G infrastructure[3] and that driving factors in adoption of 5G services will depend on the cost of end-user devices and the development of the IoT and machine-to -machine services, which are yet to be thought of. GSMA's own estimates indicate that 5G is anticipated to Represent 12% of Total Connections by 2025 while 4G Adoption is Forecast to Rise from 55% in 2020 to 67% by the Same Year. When discussing slow adoption of new services and spectrum allocations, it is necessary to maintain a fair balance in order to prevent excessive spectrum identifications that will not result in additional services in a horizon of 15-20 years.

Consider the current panorama of IMT spectrum identifications in bands near or at the mid-band range defined as frequencies between 1.8 GHz and 7 GHz, both at global level, as well as at Region 2 level

For example, Worldwide, the following footnotes identify close to 700 MHz of globally harmonized spectrum between 1.7 GHz and 2.2 GHz for IMT in the 2 and 3 GHz range:

[3] https://www.wsj.com/articles/what-holding-back-5g-rollout-11647144776?mod=rss_Technology

- Footnote 5.384A, providing a global identification in the range 1710-1885, 2300-2400, and 2500-2690 MHz ranges, for a total of 465MHz,
- Footnote 5.388, providing another global identification in the 1885-2025 MHz and 2 110-2200 MHz for IMT use, aggregating to 695 MHz

And specifically in Region 2, up to 300 additional MHz, via

- Footnote 5.429D, in the 3300 – 3400 MHz range,
- Footnote 5.431B, identifying the 3400 – 3600 MHz range for IMT
- Footnote 5.441A, identifying the 4800 – 4900 MHz range.

We note that the Caribbean countries are not listed under these country footnotes. We recall that nothing prevents any administration from joining these existing footnotes. These bands band remain with relatively low usage by the mobile service and could represent a less contentious sharing environment with existing services both in band and in adjacent band regimes. The following map presents the administrations in red that have allocated the 3.3-3.4 GHz to mobile service today:

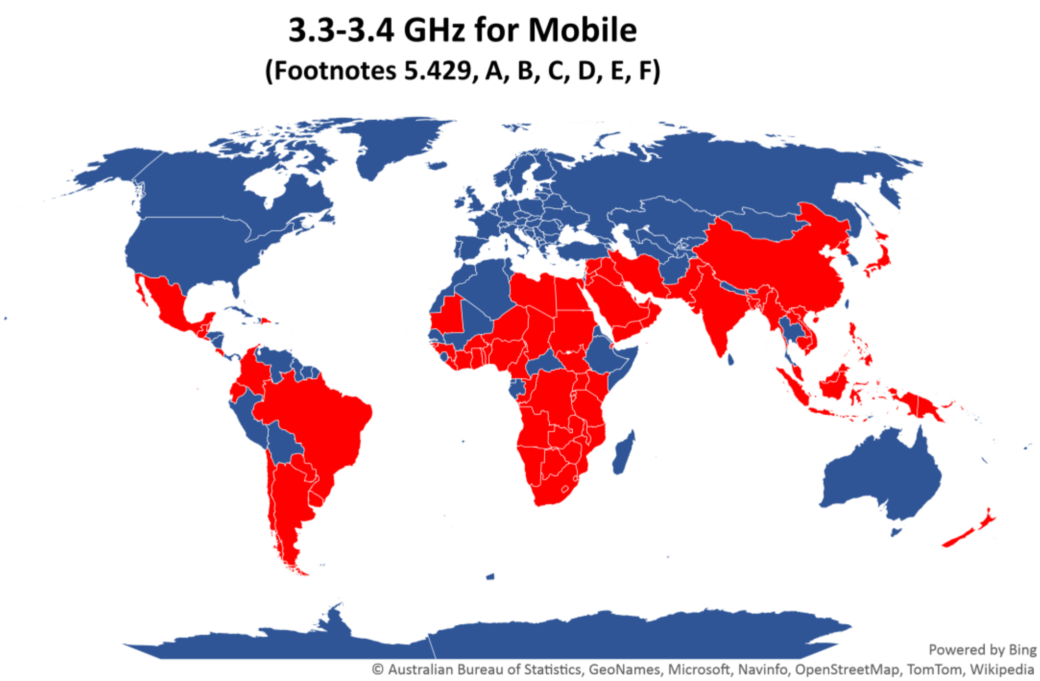

Figure 4

- The 3.4-3.6 GHz is identified on a primary basis for mobile service worldwide.

One can note that the progress towards licensing the above-mentioned bands is relatively slow and in some cases, processes have hardly begun in a number of CTU administrations[4,5]. As noted, according to the ITU RR, CTU administrations have the 1710-2025 MHz, 2110-2200 MHz, 2300-2400 MHz, 2500-2690 MHz and 3400-3600 MHz open for mobile deployment considerations today. This represents a total of 895MHz. The following table presents our understanding of the amount of spectrum licensed in each of the bands on a country-by-country basis and the amount of still available spectrum for mobile services.

Table 1. CTU usage of Mid-band spectrum per country and amount still available for mobile services today

Bands (MHz)	1710-2025	2110-2200	2300-2400	2500-2690	3400 - 3600	Total	Amount spectrum still available (MHz)
Available spectrum (MHz)	**315**	**90**	**100**	**190**	**200**	**895**	
Antigua y Barbuda	0	0	0	0	0	0	**895**
Bahamas	110	30	0	0	0	140	**755**
Barbados	112	0	0	0	0	112	**783**
Belize	0	0	0	0	0	0	**895**
Cuba	85	5	0	0	0	90	**805**
Dominica	0	0	0	0	0	0	**895**
Granada	114.8	0	0	0	0	114.8	**780.2**
Jamaica	120	40	20	60	104	344	**551**
Saint Kitts y Nevis	0	0	0	0	0	0	**895**
San Vicente y las Granadinas	0	0	0	0	0	0	**895**
Santa Lucía	0	0	0	0	0	0	**895**
Suriname	120	25	0	0	0	145	**750**
Trinidad y Tobago	95	15	0	0	0	110	**785**

As seen in the table above, depending on the country there appears to be anywhere between 500 and 895 MHz of available spectrum for mobile service implementation today.

b) Existing spectrum ready to use with a mature system ecosystem

The spectrum mentioned above already represents a total of **895 MHz** available today and aligned with existing associated 3GPP specifications. In addition, the following figure presents the status of the development of devices for each of the bands considered. It is noteworthy that all the identifications mentioned in the previous section are in the top-5 bands in terms of device availability.

[4] See for example a summary by LS Telcom in https://www.lstelcom.fr/fileadmin/content/lst/marketing/media/2019_Study_LicensingUseofMobileSpectrum.pdf

[5] CITEL document CCP.II-RADIO /doc. 5440/21 rev.1 REPORT ON IMPLEMENTATION PLANS IN THE AMERICAS FOR THE BANDS IDENTIFIED FOR IMT IN THE ITU RADIO REGULATIONS

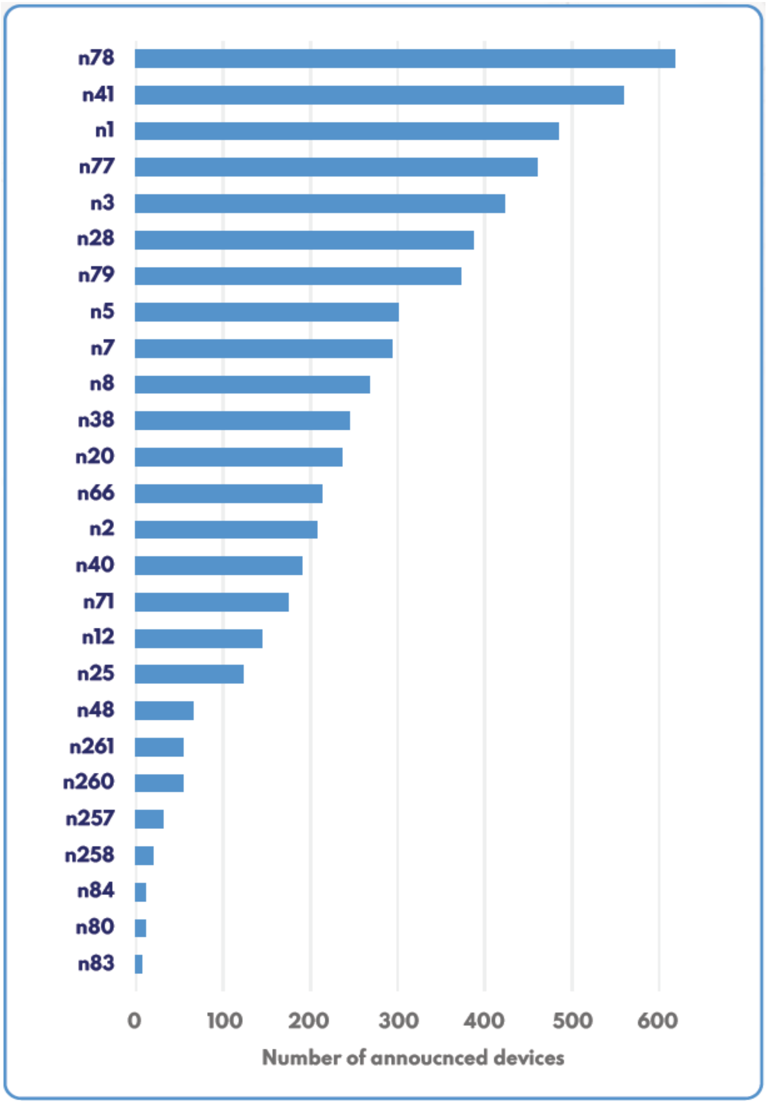

Figure 5. Number of user devices in each 5G band.
Source:GSA, 5G Market Snapshot, August 2021

- n78 or 3300-3800 MHz (TDD) - including 3300-3400MHz- represents the most popular band with around 600 planned devices..
- n41 or 2496-2690 MHz (TDD) is the second most mature band with around 550 devices.
- n1 or 1920-1980 MHz and 2110-2170 MHz (FDD) the third most popular with 500 devices.
- n3 or 1710 MHz-1785 and 1805-1880 MHz (FDD) is also a popular band with around 430 devices.

c) Mobile use in mid-band spectrum (1.7-7 GHz) is going to be for urban environments only

It is important to note that C-band mobile spectrum is aimed solely for urbanized deployments. The GSMA Intelligence report entitled "Economic benefits of using the 3.5 GHz range (3.3-4.2 GHz) for mobile" states, concerning C-band spectrum, that: "*.. the model only considers benefits to the urban population. Due to its technical characteristics, it is expected that this is going to be the primary use of the band*".

Over recent years, many countries have licensed UHF frequency bands such as the 800 MHz band to their mobile operators. These lower frequencies are ideal for providing wide-area coverage due to their improved propagation characteristics compared to higher frequencies.

Most European and Asian countries, which have already invested heavily in 4G, are only using mobile C-band for capacity infill in cities, leveraging mobile NR Phase 1 capability. Phase 1 (non-standalone mode) uses existing LTE coverage to carry out control functions, with data capacity provided by a mobile only if additional, overlapping coverage is available. As such, in the first phase of mobile roll-out, a 4G network is required to handle the command-and-control functions, meaning that mobile coverage cannot extend beyond any existing 4G coverage. In the second phase of stand-alone mobile, it is expected that lower frequency (i.e. 700 MHz) coverage will be needed as a command-and-control, and coverage layer to support capacity hotspots in higher frequency bands (i.e. C-band or mmWave).

It is critical to ensure that the C-band frequencies remains available for satellite operations on an interference free basis. There have been long-lasting debates on the use of C-band spectrum for mobile services in the band to develop mobile for urbanised areas. Therefore, a balanced approach needs to be struck to allow C-band satellite services to continue to operate and provide connectivity solutions in remote areas.

d) Reasons why mobile does not require 100 MHz contiguous spectrum here

The main reasons why IMT operators are demanding 100 MHz of contiguous spectrum in the C-band have been as follows:

- 100 MHz is the MNO's ideal situation (and one never argues for a compromise as an opening gambit).
- C-band is green-field spectrum in which operators can deploy their networks without needing to re-farm spectrum in other bands allowing more rapid deployment and lower roll-out costs.

IMT operators have exposed their arguments arguing for 100 MHz of contiguous spectrum in the C-band is important to ensure 5G headline speeds and to satisfy what they believe their users are expecting.

There is however no evidence that 80-100 MHz of contiguous C-band spectrum per MNO is an absolute requirement to achieve 5G, as proven by the fact that most 5G auctions occurred globally did not imply the grant of 100 MHz contiguous spectrum (See Appendix A). In the response to the MNOs' claims they need access to at least 80 MHz of contiguous spectrum, Ofcom, the communications regulator in the United Kingdom [6], researched the ability of mobile operators to launch 5G services with 40 MHz of spectrum. Such research found that *"(…) there was no evidence that 5G could not be delivered with smaller [e.g. 40 MHz blocks] or non-contiguous carriers in other frequency bands [i.e. spectrum other than C-band]."* To support its finding that 40 MHz of C-band spectrum was sufficient to provide 5G services, Ofcom developed a theoretical cell site throughput model to estimate network performance based on various assumptions on the type of antenna used, bandwidth of C-band carrier, and signal strength received by the user. The results clearly demonstrate that terrestrial mobile operators will be able to deliver all the main services anticipated under 5G – including, but not limited to, connected cars, virtual reality cloud broadband, and live 4K streaming – with 40 MHz of spectrum. Figures 1 and 2 shows that results of Ofcom studies clearly demonstrate that mobile operators will be able to provide all the main services provided for in the 5G - including, among others, connected cars,

[6] *See*, Ofcom, *§A7.39, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: Annexes* (13 March 2020), available online at https://www.ofcom.org.uk/data/assets/pdf_file/0017/192410/annexes-award-700mhz-3.6-3.8ghz-spectrum.pdf.

broadband in the virtual reality cloud and streaming to live in 4K - with 40 MHz of spectrum. Mobile operators may want an 80 to 100 MHz spectrum from the C-band for optimal performance, but they don't need it to offer high quality to remain competitive.

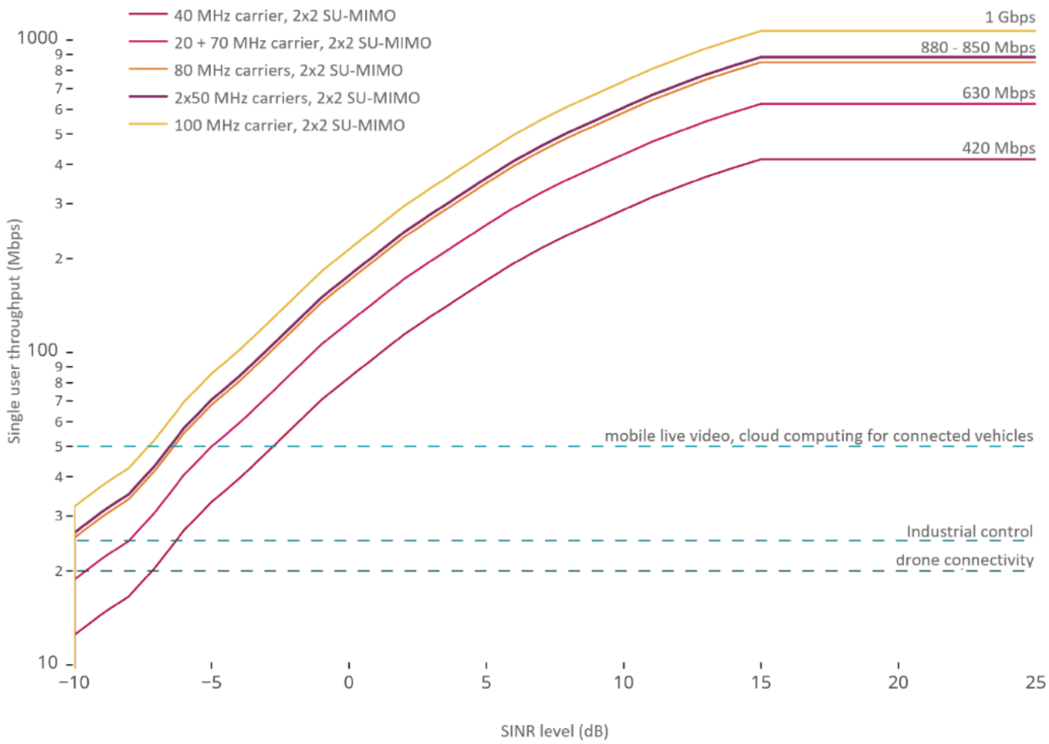

Figure 6. Downlink throughput for a single user (SUT) across different signal levels in a cell compared to the minimum rate required for some 5G services[7]

[7] *See*, Ofcom, *Figure A7.26, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: Annexes* (13 March 2020), available online at https://www.ofcom.org.uk/data/assets/pdf_file/0017/192410/annexes-award-700mhz-3.6-3.8ghz-spectrum.pdf.

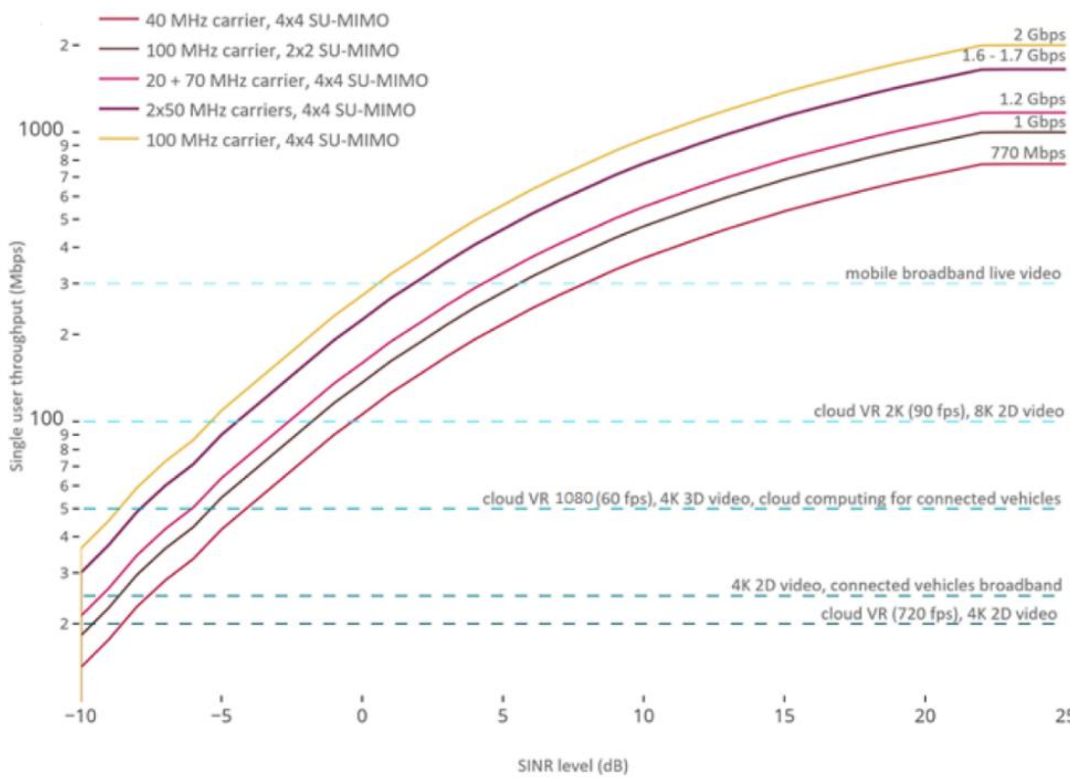

Figure 7. Downlink throughput for a single user (SUT) across different signal levels in a cell compared to the minimum rate required for some 5G services[8]

In addition, the mobile industry is arguing for 100MHz of contiguous spectrum for the delivery of Ultra-reliable Low Latency Communications (URLLC). URLLC is a specialist application more suited to specific instances and not for general (public) use and as such is unlikely to generate the revenues needed to fund widespread 5G roll-out. ITU-R Report M.2410-2017 “Minimum requirements related to technical performance for IMT-2020 radio interface(s)” recommends 100 MHz as the minimum bandwidth required for URLLC (and eMBB). However, it also says that the required 100 MHz can be achieved through multiple carriers: there is no requirement to achieve the 100 MHz through a single carrier using a single contiguous block. URLLC is also not considered a high bandwidth or data-hungry service.

The 5G standard allows for the resource block sizes needed for URLLC in a 50MHz bandwidth which has additional advantages regarding the required signal strength and therefore the service range of the site.[9] It is important to emphasize that this specialist application would be deployed at specific locations such as campus and industrial sites but not on a general network. URLLC would be better

[8] *See*, Ofcom, *Figure A7.27, Award of the 700 MHz and 3.6-3.8 GHz spectrum bands: Annexes* (13 March 2020), available online at https://www.ofcom.org.uk/data/assets/pdf_file/0017/192410/annexes-award-700mhz-3.6-3.8ghz-spectrum.pdf.

[9] ShareTechNote.com. 5G Frame Structure. https://www.sharetechnote.com/html/5G/5G_FrameStructure.html

suited to unencumbered bands free from neighboring operators, making the mmWave spectrum far better suited for this application than C-band.

3 Proposal

a) Overview of the situation in CTU

This paper showed that there is still an important use of C-band satellite services in the region using 3.6-3.8 GHz (24%) that are particularly suited to the topography and climate. In addition, all the mid-band spectrum mentioned above equates to about 995 MHz (this is including the 3.3-3.4 GHz) of spectrum which should be enough to accommodate the needs of CTU administrations' national operators for mobile operations in the mid-band spectrum. As seen in Table 1 in section 2a), most CTU administrations still have a lot of available spectrum today for mobile service deployments in or at the mid-band frequency range, without the need for an additional 200 MHz in 3.6-3.8 GHz.

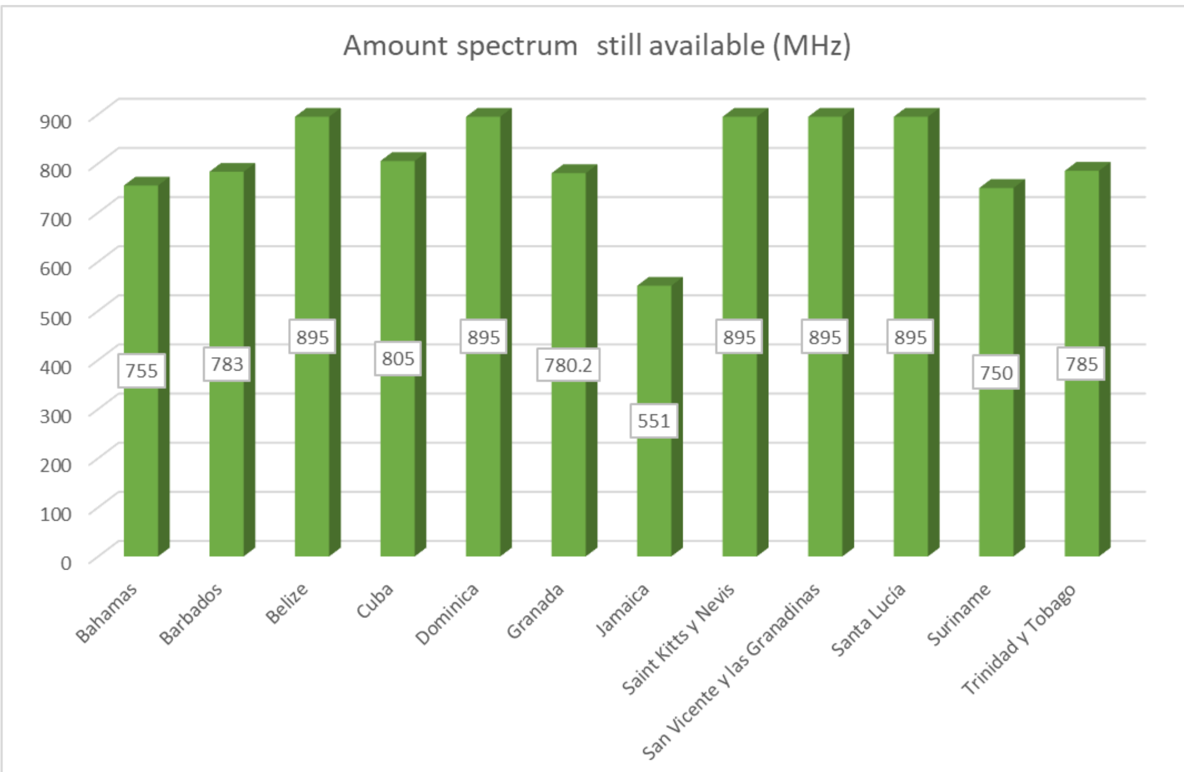

Figure 8. Mid-band mobile spectrum available today in CTU countries

b) Proposed methods to satisfy the agenda item

This paper was aimed at exposing the background around the current push for additional mobile IMT mid-band spectrum and to think about a balanced proposal to the CPM methods to satisfy Agenda Item 1.2. Based on the arguments exposed throughout this paper, we would suggest proposing the following methods to the upcoming 5A meeting:

Method A: NOC