Viasat

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Re: Long-Term Spectrum Outlook Public Consultation

Viasat South Africa PTY Ltd and Viasat, Inc. (collectively, "Viasat") is grateful for the opportunity to submit comments to the Independent Communications Authority of South Africa ("ICASA") on the Long-Term Spectrum Outlook for South Africa for Public Consultation ("Consultation")[1]. Viasat submits the comments below to describe the connectivity services that Viasat is planning to offer in South Africa and the spectrum resources and policies that will facilitate the deployment of those services.

EXECUTIVE SUMMARY

Viasat, Inc. is a global provider of communications solutions and broadband services across a wide variety of technologies, both satellite and terrestrial. Viasat appreciates ICASA's recognition in the Consultation that it is now established in South Africa and preparing to offer broadband services[2]. Viasat is committed to powering hundreds of millions of connections around the globe, including in South Africa, on land, in the air, and at sea. Our next generation Ka-band very high-throughput satellite constellation – ViaSat-3 – will enable the provision of cost-effective bandwidth to power South Africa's key economic verticals, including the public sector, healthcare, agriculture, and education, connect the unserved and underserved, and accelerate digital transformation across South Africa.

[1] *See Government Gazette Staatskoerant*, Republic of South Africa, Gazette No. 45690, Page No. 77 (24 December 2021), Independent Communications Authority of South Africa, Long-Term Spectrum Outlook for Public Consultation, https://www.icasa.org.za/legislation-and-regulations/inquiries/long-term-spectrum-outlook.

[2] Consultation at Section 4.3.8, p. 4-47.

Viasat is currently deploying internet connectivity and implementing a digital learning center at Emtshibeni Junior Secondary School, Corrinth, Harry Gwala Municipality. The school's student population is 820 people ranging in age 12 to 20 years. There is no current connectivity available at the school. A single classroom catering for 30 students at any point in time during school hours will be equipped with devices and a large screen for teacher led digital learning programs, the classroom will have a 5 Mbps connection allowing the students to go on-line for educational purposes, during digital learning sessions. The digital learning center will be branded Viasat. The above services will be provided by Viasat free of charge to the school.

Viasat's satellite technology uses the 17.7-21.2 GHz (downlink) and 27.5-31 GHz (uplink) portions of the Ka band to offer a wide range of satellite broadband services around the world to fixed locations in urban, sub-urban, and rural locations, and to ubiquitous mobile users via earth stations in motion (ESIM). ESIM provide broadband for gate-to-gate aeronautical and pier-to-pier maritime services as well as for land-based mobile users, such as emergency response vehicles, and buses and trains that require advanced broadband solutions within South Africa. Viasat's technology is also vital to the Defence sector, with applications to provide "anywhere, anytime" assured communications, instant access to intelligence, surveillance, and reconnaissance (ISR) video, maps, voice, and data.

In the responses below to ICASA's Consultation, and in order to be able to offer the full benefits of the connectivity services described above, Viasat needs access to adequate spectrum resources in South Africa that permit existing and future broadband services over its network to benefit South African users throughout the country. In the comments below Viasat recommends that ICASA:

- preserve the 27.5-29.5 GHz (28 GHz) portion of the Ka band for satellite services;
- identify internationally harmonized spectrum in the 24.25-27.5 GHz (26 GHz) and other bands identified by the WRC-19 for terrestrial IMT/5G;
- protect competition by ensuring geostationary (GSO) networks are protected from interference from NGSO systems by conditioning NGSO systems' market access on angular separation from GSO networks; and

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- ensure competition between NGSO systems by requiring NGSO systems to equitably share spectrum when there are in-line events between NGSO systems.

Viasat responses to applicable consultation questions:

Question 12: Provide your support or reasons for objections on the bands being considered internationally for 5G commercial mobile allocations.

Viasat Response: Viasat supports ICASA's proposal to identify the 24.25-27.5 GHz (26 GHz) band for International Mobile Telecommunications (IMT) in the National Radio Frequency Plan (NFRP) 2021 consultation,[3] also known as terrestrial IMT/5G, with the adoption of Footnote 5.532AB[4] as well as other millimetre wave (mmWave) bands identified for terrestrial IMT/5G by WRC-19[5]. Viasat also supports ICASA's proposal in the consultation that the 26 GHz band is the right band for accommodating any requirements for mmWave spectrum for terrestrial IMT/5G. To date, there has been little usage of the 26 GHz band internationally due to limited demand for terrestrial use of mmWave given the uncertainty of the business case for this band. Thus, Viasat recommends that ICASA adopt an approach that accommodates any future demand for terrestrial IMT/5G mmWave services in the 26 GHz band and other bands identified for terrestrial IMT/5G, while also appropriately protecting existing services, including satellite-powered broadband services operating in the adjacent 28 GHz band. International research confirms that the mmWave band is not an option being prioritized globally for terrestrial IMT/5G services (see Figure 1 below).

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3 *See Government Gazette Staatskoerant*, Republic of South Africa, Gazette No. 44803, Page No. 3 (9 July 2021), General Notices, Independent Communications Authority of South Africa, Draft National Radio Frequency Plan 2021 for Public Consultation, https://www.icasa.org.za/legislation-and-regulations/radio-frequency-spectrum-plans/draft-radio-frequency-spectrum-plans.

4 ITU Radio Regulations Footnote 5.532AB states: "The frequency band 24.25-27.5 GHz is identified for use by administrations wishing to implement the terrestrial component of International Mobile Telecommunications (IMT). This identification does not preclude the use of this frequency band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations. Resolution 242 (WRC-19) applies."

5 *See* ITU Press Release, *WRC-19 identifies additional frequency bands for 5G*, (Nov. 22, 2020) (those bands include the following: 24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz), https://news.itu.int/wrc-19-agrees-to-identify-new-frequency-bands-for-5g/.

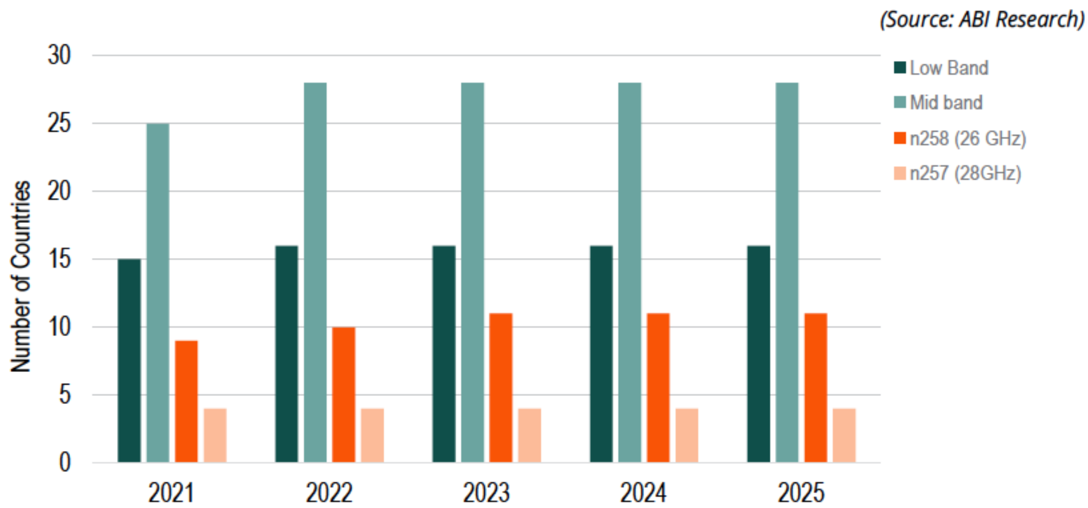

Figure 1: ABI Research: Emerging Markets Broadband Objectives: Spectrum Requirements (ABI, 2021)
https://go.abiresearch.com/lp-emerging-markets-broadband-objectives-spectrum-requirements.

The ITU WRC-19 designated over 17 gigahertz of spectrum for terrestrial IMT/5G in the mmWave bands, including the 26 GHz band[6]. Viasat urges ICASA to take the vast amount of spectrum available for terrestrial IMT/5G in the mmWave bands, identified by WRC-19, and the additional low-band and mid-band spectrum being made available in countries around the world for terrestrial IMT/5G, into account as part of its overall review of spectrum for terrestrial IMT/5G services.

Viasat has supported the study and the development of reasonable operating parameters for terrestrial IMT/5G in the 26 GHz band through the ITU WRC-19 process. To this end, Viasat urges ICASA to conform domestic deployment of terrestrial IMT/5G in the 26 GHz band to the operating parameters decided in Resolution 242 (WRC-19) as well as additional out-of-band domain and spurious domain emission limits described below. Viasat emphasizes the importance of the portion of Resolution 242 (WRC-19) that requires IMT/5G base stations within the 26 GHz band with higher power operations

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6 *See* ITU Press Release, *WRC-19 identifies additional frequency bands for 5G*, (22 Nov. 2020) (those bands include the following: 24.25-27.5 GHz, 37-43.5 GHz, 45.5-47 GHz, 47.2-48.2 and 66-71 GHz), https://news.itu.int/wrc-19-agrees-to-identify-new-frequency-bands-for-5g/.

(e.i.r.p per beam exceeding 30 dB (W/200 MHz)) to not point their antenna beams upward at the geostationary satellite orbit and maintain a minimum separation angle of ≥± 7.5 degrees.

Viasat, as with many satellite operators, uses the 28 GHz band for fixed and mobile satellite-powered broadband, including ubiquitous GSO ESIM services. As such, we are concerned about potential out-of-band emissions from 26 GHz band terrestrial IMT/5G systems into the 28 GHz band. Any increases in power by terrestrial IMT/5G systems in the 26 GHz band, beyond those specified in Resolution 242 (WRC-19), would increase out-of-band emissions in the 28 GHz band. The potential impact of increased out-of-band emissions from the 26 GHz band could adversely affect the interference environment in the 28 GHz band by impacting the ability of satellites receiving signals from earth stations. Therefore, we respectfully request that ICASA require appropriate out-of-band limitations on terrestrial IMT/5G operations to protect satellite services in the 28 GHz band. At a minimum, terrestrial IMT/5G stations should be required to comply with out-of-band domain and spurious domain emission limits in the frequencies above 27.5 GHz as described in Recommendations ITU-R SM. 1541-6 and ITU-R SM. 239. In the case of ITU-R SM.329, the category B limits should apply. Viasat also requests that ICASA ensure that the *aggregate level* of terrestrial out-of-band emissions from the 26 GHz band into the adjacent 28 GHz band does not cause interference to satellite receivers in the 28 GHz band.

Question 13: Are the spectrum allocations comprehensive enough for spectrum demand projections for commercial mobile services in South Africa for the next 10 to 20 years?

Viasat Response: ICASA are more likely to achieve a successful deployment of mmWave spectrum for terrestrial IMT/5G once there is a more defined market outlook for terrestrial IMT/5G in the mmWave bands. Despite the minimal global deployment of mmWave in general thus far, the 26 GHz (*i.e.*, 24.25-27.5 GHz) band enjoys a global identification and harmonization by the ITU for terrestrial IMT/5G that provides a vast amount of spectrum (3.25 GHz) for cellular licensees in South Africa. The 28 GHz band (*i.e.*, 27.5-29.5 GHz) should be assigned for satellite-powered broadband in South Africa to enable ubiquitous broadband connectivity (FSS and ubiquitous ESIM), maritime and aeronautical connectivity, in line with international adoption across Europe, China, Russia, Australia and over 120 other countries globally.

Question 39: **What will impact on the demand for these [satellite] services/applications in the coming 10-20 years? What is realistic demand for these services in the next 10 to 20 years? Are there adequate spectrum allocations for Satellite services in South Africa?**

Viasat Response: See response to question 40, below.

Question 40: **Which applications and allocations will require the most frequency spectrum demand in the following bands?**

- **C-band**
- **Ku-band**
- **Ka-band**

Viasat Response: ***International Consensus Provides for the 27.5-31 GHz and 17.7-21.2 GHz Bands to Extend Satellite Broadband Connectivity Throughout the World***

In a series of actions over the past six years, the international community has affirmed the importance of retaining the 27.5-31 GHz uplink band, and the corresponding 17.7-21.2 GHz downlink band for satellite-powered connectivity to end users. The first two steps occurred in 2015 in (i) an ITU decision that validated use of the 29.5-30 GHz and 19.7-20.2 GHz segments to extend satellite broadband connectivity to earth stations in motion (ESIM), including the types of end user terminals that enable Wi-Fi connectivity on airplanes[7], and (ii) another ITU decision that directed that the adjacent 27.5-29.5 GHz and 17.7-19.7 GHz segments also be validated for ESIM use in order to extend global broadband connectivity by satellite[8].

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7 ITU Resolution 156 (WRC-15) "Use of the frequency bands 19.7-20.2 GHz and 29.5-30 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service."

8 ITU Resolution 158 (WRC-15), considering "d" ("there is a need for mobile communications, including global broadband satellite services, and that some of this need can be met by allowing earth stations in motion to communicate with space stations of the FSS operating in the frequency bands 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space)"); considering further "a" ("a consistent approach to deployment of these earth stations in motion will support these important and growing global communication requirements").

The third step occurred in 2015 when, in identifying possible spectrum for 5G/IMT services, the ITU expressly rejected consideration of the 27.5-31 GHz portion of the Ka Band for those purposes, because of the existing use of that spectrum for satellite broadband services, and the unique needs of terrestrial IMT/5G services, which are not compatible with satellite broadband services.[9]

The fourth and fifth steps occurred in 2019 when the ITU (i) decided to locate terrestrial IMT/5G services into over 17 gigahertz of separate spectrum specifically designated for that purpose, including the adjacent, but separate, 24.25-27.5 GHz band,[10] and (ii) validated GSO ESIM use of the 27.5-29.5 GHz and 17.7-19.7 GHz segments in order to extend global broadband connectivity by satellite.[11]

As a result, satellite operators have designed, constructed, and deployed satellite broadband networks around the world based on these ITU decisions, and the longstanding global allocations for satellite services in the 27.5-31 GHz and 17.7-21.2 GHz bands.

That global consensus continues to be affirmed. Over 120 countries (a rising number) have expressed their intention to follow the ITU decisions and preserve the 27.5-31 GHz and 17.7-21.2 GHz bands for satellite broadband services. By way of example, Europe's "5G Roadmap" affirms this determination, recognizing the critical nature of this spectrum for satellite broadband, and expressing its policy: "Signal clearly that Europe has

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9 http://interactive.satellitetoday.com/how-wrc-15-led-to-the-big-c-band-decision. At WRC-15, the 27.5-29.5 GHz band was discussed, and rejected, as a possible 5G candidate band. 29.5-31 GHz was not even considered.

10 ITU Press Release, *WRC-19 identifies additional frequency bands for 5G,* Nov. 22, 2019 ("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 networks, 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 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. Out of this number, 14.75 GHz of spectrum has been harmonized worldwide, reaching 85% of global harmonization.") https://news.itu.int/wrc-19-agrees-to-identify-new-frequency-bands-for-5g/.

11 ITU Resolution 169 (WRC-19) "Use of the frequency bands 17.7-19.7 GHz and 27.5-29.5 GHz by earth stations in motion communicating with geostationary space stations in the fixed-satellite service."

harmonised the 27.5-29.5 GHz band for broadband satellite and is supportive of the worldwide use of this band for ESIM. This band is therefore not available for 5G"[12].

Approximately 3.5 billion people represented by Europe, Indonesia, Australia, China, Russia, Bangladesh, Nigeria, Kenya, Brazil, Mexico and virtually all of Latin America, to name a few, support preserving the 27.5-31 GHz and 17.7-21.2 GHz bands for satellite and accommodating terrestrial IMT/5G needs in separate spectrum. Of course, this will drive scale for use of the 27.5-31 GHz and 17.7-21.2 GHz bands by satellite systems and end users, and similarly will drive scale for terrestrial IMT/5G equipment in separate spectrum.

Question 41: **What and how will technology developments and/or usage trends aid in relieving traffic pressures and addressing spectrum demand for satellite services? When are these technologies expected to become available?**

Viasat Response: As detailed below, spectrum access directly affects satellite capacity, and thus the ability to serve South Africa in a cost-effective manner. This is why we respectfully request that ICASA retain satellite access to the *full* Ka band (*i.e.*, 27.5-31 GHz uplink and 17.7-21.2 GHz downlink) for service links to and from end users—those individuals that benefit from satellite connectivity. Any reduction in the satellite spectrum available to serve end users would reduce the number of people that can be served by a given satellite, and also would reduce its cost-effectiveness to the detriment of end users.

Today, satellite-powered broadband bridges the digital divide, connecting the unconnected in underserved and unserved areas across the world with affordable connectivity they would not otherwise have. These broadband services are made possible because the International Table of Frequency Allocations makes available the 27.5-31 GHz and 17.7-21.2 GHz bands for satellite services, and the vast majority of countries are following international consensus and making this spectrum available

[12] *See* European Conference of Postal and Telecommunications Administrations (CEPT), *Spectrum for wireless broadband – 5G*, Section B.3 (Version 10, Revised 6 March 2020) at https://www.cept.org/Documents/ecc/57839/ecc-20-055-annex-15_cept_5g_roadmap.

domestically for service directly to end users via small, easy to install satellite terminals. The 27.5-31 GHz band is used for communications transmissions from end users to satellites; the 17.7-21.2 GHz band is used for communications transmissions from satellites back to the end users.

As detailed below, access to the 27.5-31 GHz and 17.7-21.2 GHz spectrum bands for user terminals is critical to enabling the *cost-effective* provision of satellite-powered broadband to citizens of South Africa. Viasat is not aware of any terrestrial service provider proposing to offer this type of connectivity using this spectrum. The terrestrial services being proposed in mmWave bands will be specialized or limited in reach in terms of population.

As an initial matter, we emphasize that the nature of satellite networks allows many different satellite providers to use the same spectrum to serve the same geographic area without interfering with each other. Satellite systems regularly share access to the same radio spectrum by operating with angular separation from each other, so that each one operates with different lines of sight to and from a given location on Earth. This approach has worked well for half of a century and has enabled equitable access to the limited and shared spectrum resource, and intensive reuse of that resource, consistent with long-established international principles. This concept is depicted for geostationary (GSO) satellites in Figures 2 below.

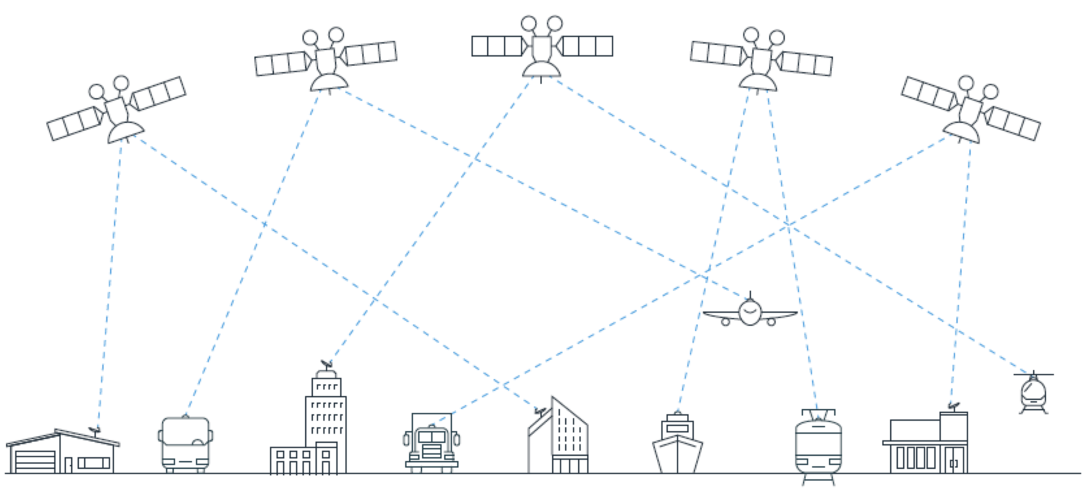

Figure 2: Angular Separation Between Satellites in the GSO Arc.

Adequate Spectrum for End User Communications Enables Satellite-Powered Broadband

Satellite broadband networks provide service to end users by employing separate communications transmission paths from (i) end users to the satellite (uplinks); (ii) the satellite to gateways that interconnect to the Internet (downlinks); (iii) the gateways back to the satellite (uplinks); and (iv) the satellite back to the end users (downlinks). As noted above, the 27.5-31 GHz band is used for transmissions *to* the satellite; the 17.7-21.2 GHz band is used for communications transmissions *from* the satellite. This is depicted in Figure 3.

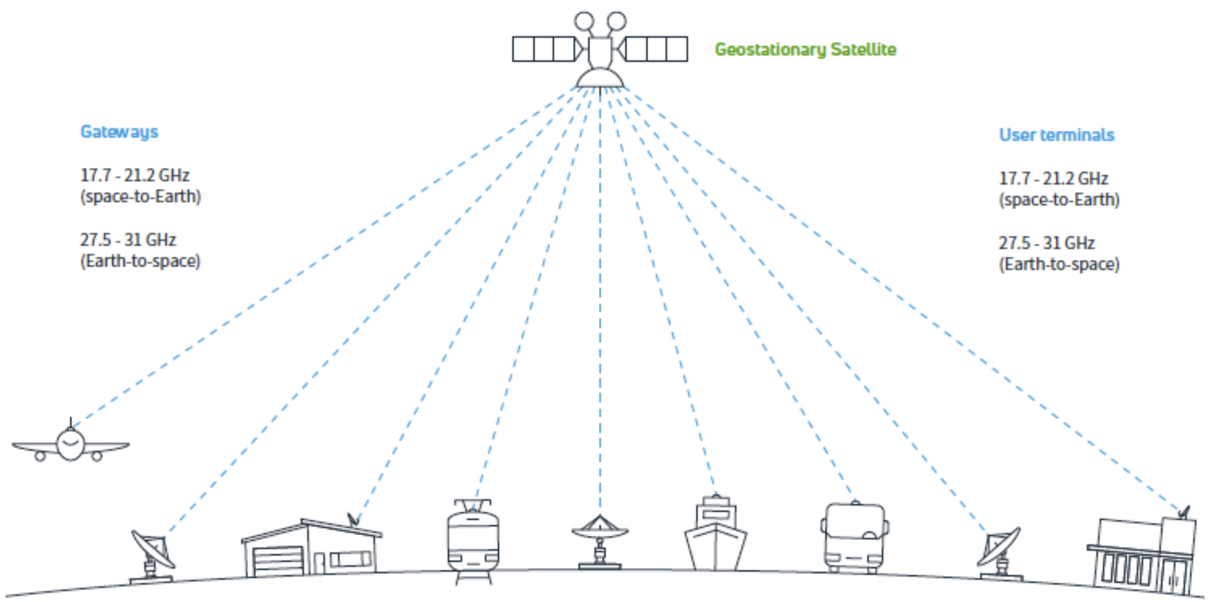

Figure 3: 27.5-31 GHz (Earth-to-space) and 17.7-21.2 (space-to-Earth) Bands Needed for Both Satellite Gateways and Their Fixed and Mobile User Terminals.

As depicted in Figure 4, the amount of capacity that can be provided on a single satellite has increased by factor of ~ 500x in the recent past, and it will continue to improve in the next few years as even more advanced satellite designs are implemented. The ability to deliver more and more capacity over a single satellite results in a corresponding reduction (~400x) of the cost of delivering service. These exponential increases in capacity (and in cost-efficiency) are made possible by designing satellites to serve end users by utilizing the entire 27.5-31 GHz and 17.7-21.2 GHz bands designated by the international community for satellite-powered broadband, and by reusing this spectrum on a given satellite many times over.

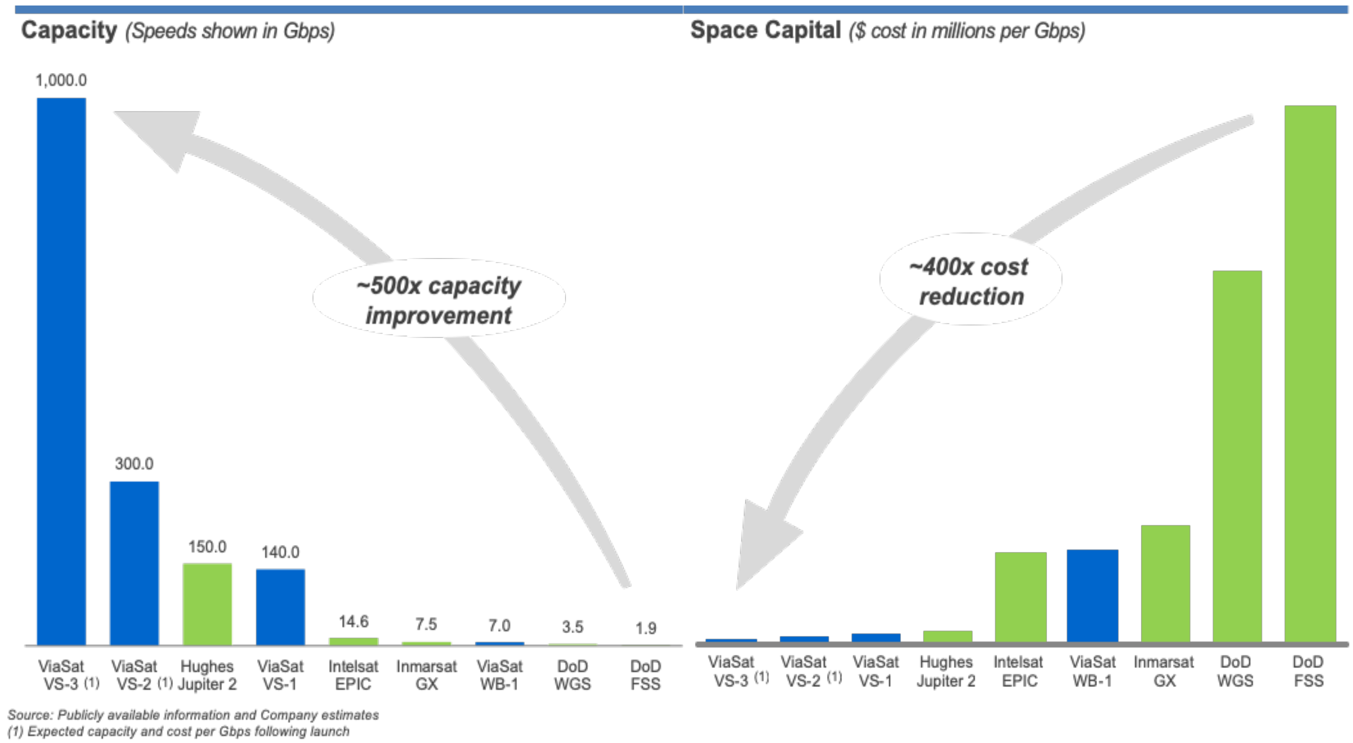

Figure 4: Exponential Increases in Satellite Broadband Capacity and Reductions in Cost.

Each ViaSat-3 satellite currently under construction is designed to yield both (i) an unprecedented +1 Terabit per second of total throughput and (ii) end user speeds of up to 1 Gigabit per second. The next iteration of the Viasat satellite design (ViaSat-4) uses the same 27.5-31 GHz and 17.7-21.2 GHz spectrum and yields between 5 and 7 Terabits per second of total throughput per satellite, reducing costs even more than as depicted above.

Figure 5 provides another comparative analysis of the cost-effectiveness of the most advanced broadband satellites being deployed. As indicated below, the greatest efficiencies are delivered by geostationary satellites that utilize the full 27.5-31 GHz and 17.7-21.2 GHz spectrum bands.

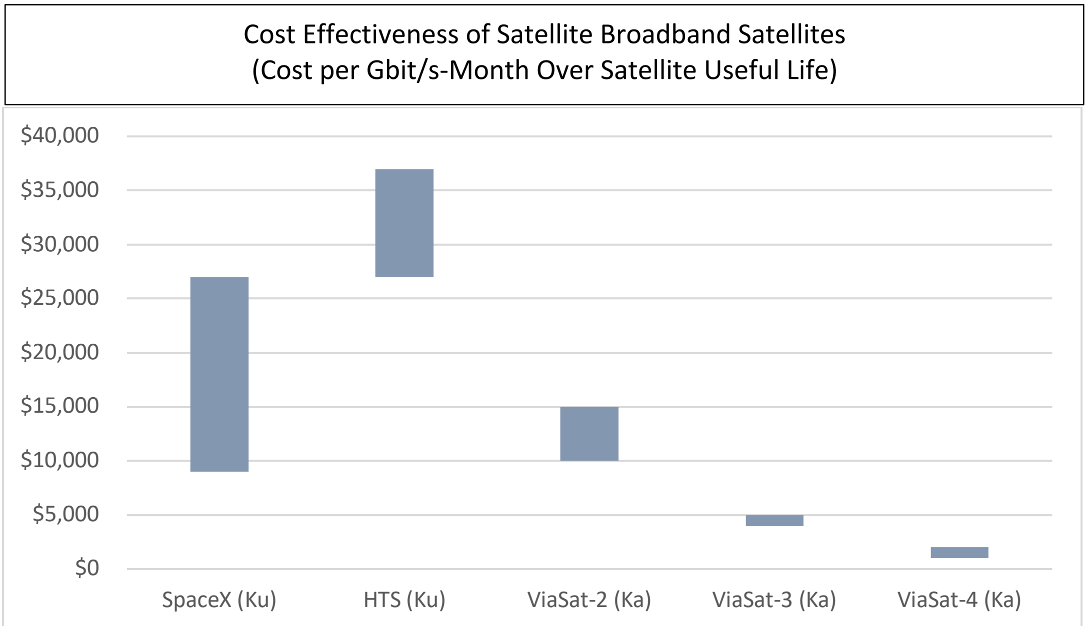

Figure 5: Ultra-High-Throughput Ka Band Satellites Change the Economics of Satellite Broadband[13].

Intensive Reuse of 27.5-31 GHz and 17.7-21.2 GHz Spectrum Provides Superior Performance and Cost-Effectiveness

The ViaSat-3 and ViaSat-4 networks are designed to eliminate all possible capacity bottlenecks in order to dramatically improve the end user connectivity experience. To provide the capacity that enables the provision of reliable and affordable satellite broadband connectivity to end users, spectrum in the 27.5-31 GHz and 17.7-21.2 GHz bands is intensively reused within these satellite networks.

One key element to achieving exceptionally high spectrum reuse within a satellite network is increasing the number of spot beams on a satellite. Within a satellite's area of coverage, there may be many thousands of beams. The spot beams look like a honeycomb pattern on the Earth's surface, similar to cell sites in terrestrial networks.

[13] Source: Morgan Stanley, July 20, 2020. ViaSat-4 annotation provided by Viasat. Frequency bands specified (Ku, Ka) are those employed for end user service.

Figure 6 provides a few examples of ways to reuse the same spectrum in different geographic areas of the satellite footprint on the Earth, with each color representing a different channel of the available spectrum being used in a given beam at a given time.

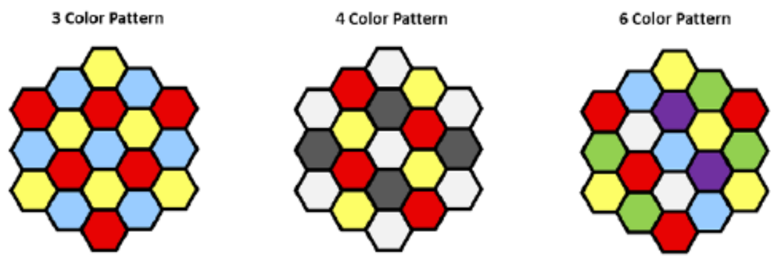

Figure 6: Examples of Satellite Spot Beams and Spectrum Reuse.

To ensure that adjacent beams do not interfere with each other, different frequencies are employed in each adjacent beam. In non-adjacent beams, frequencies are reused because the physical separation between the beams keeps the frequency uses from overlapping and causing self-interference. This reuse of spectrum allows for many end users in the same satellite footprint to access the satellite broadband signals without service degradation. The more often frequencies are reused within a satellite footprint, the more capacity that is available and the higher the number of end users that can be cost-effectively served.

Contiguous Spectrum for Satellite Broadband Enables Cost-Effective Connectivity for End Users

Contiguous spectrum access for satellite broadband—for example, in the entire 27.5-31 GHz and 17.7-21.2 GHz bands—allows use of channel plans that maximize spectrum use by enabling efficient adjacent channel satellite operations. Doing so also minimizes interference from services in adjacent bands, including out of band emissions, that otherwise would need to be managed with respect to non-contiguous band segments. If spectrum for a satellite service is not contiguous or other services are interleaved within the satellite bands, the potential for capacity-reducing interference exists, as does the need to implement spectrum-wasting mitigation techniques, such as guard bands that no service can use. As noted above, a reduction in usable spectrum has a direct impact on satellite capacity. Having contiguous spectrum for satellite broadband service also allows for modem chips and equipment that scale in an efficient way—all critical for delivering cost-effective connectivity solutions to hundreds of millions of end users.

Access to Adequate Spectrum Is the Main Limitation in Serving End Users

Access to adequate spectrum is now the primary limiting factor in extending satellite-powered broadband connectivity to end users. Spectral efficiency determines how much information can be delivered in a unit of spectrum. Today's satellite broadband systems are approaching "Shannon's Limit" in terms of spectral efficiency[14]—that is, actual transmissions are near the maximum capacity that theoretically can be achieved over a given amount of spectrum and within the regulatory transmission power limits. This is another reason why it is critical to retain the entire 27.5-31 GHz and 17.7-21.2 GHz bands for satellite broadband, and to accommodate terrestrial IMT/5G services in separate spectrum designated for their unique purposes.

Question 52: **Due to the scarcity of high demand spectrum and the consequential fact that Spectrum Sharing in certain bands are non-negotiable, how shall you describe the best sharing conditions for the South African scenario?**

Viasat Response: As mentioned above, GSO networks have been able to share spectrum resources efficiently, using angular separation. While this has been sufficient in the past, where only GSO networks were applying for FSS service licenses that were not mutually exclusive, consideration is required for situations where GSO and NGSO operators would apply for licenses using the same spectrum resources. Novel NGSO constellation designs with large numbers of satellites can preclude other operators in both NGSO and GSO from operating effectively.

NGSO systems have obligations to protect GSO networks from interference. These obligations stem from the ITU Radio Regulations and principles of efficient spectrum management at the national level. GSO and NGSO applications must be considered separately. For GSO networks, a first-come, first-served procedure works well – GSO

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14 *See* M. Viswanathan, *Channel Capacity & Shannon's theorem - demystified*, GAUSSIANWAVES (23 April 2008), https://www.gaussianwaves.com/2008/04/channel-capacity/.

networks are usually coordinated prior to applying for market access, and separation and orbital spacing along the GSO arc ensures that interference is minimal, and spectrum is shared with other GSO networks. On the other hand, NGSO constellations must protect GSO networks from unacceptable interference and can cause significant interference to GSO networks, particularly if NGSO systems do not operate with suitable a GSO avoidance angle. Below, Viasat provides information and potential solutions for ICASA's consideration on GSO-NGSO spectrum sharing and how interference protection for GSO networks can be ensured with little or no impact to NGSO networks.

Viasat urges ICASA to adopt rules for market access ensuring that NGSO systems do not cause unacceptable interference to GSO networks, and that shared radio frequencies and associated orbits are used rationally, efficiently and economically by multiple NGSOs, and that all NGSOs have equitable access to those orbits and frequencies.

GSO-NGSO Spectrum Sharing

GSO-to-GSO spectrum sharing is a relatively simple process whereby GSO network operators coordinate operations on Earth and at the GSO arc through orbital arc spacing (*i.e.*, "angular separation" between their satellites in space at fixed points in the sky relative to Earth). NGSO systems, by contrast, have fast moving satellites that create new challenges as their satellites are tracked by gateways and user terminals across the sky. These movements across the sky create opportunities for time varying interference not just into other NGSO systems but also into GSO networks. As is the case between NGSO systems, without appropriate mitigation measures, in-line events can occur between NGSO systems and GSO networks and repeatedly degrade and disrupt services to end users.

Today's Ka band Ultra High Throughput (UHT) GSO satellites are extremely efficient in how they use spectrum to provide innovative services with smaller user terminals than ever possible before. Taking advantage of the advancements in technology, satellites like ViaSat-3 are capable of providing more than 1 Tbit/s of total capacity each and

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dynamically direct capacity and coverage where and when it is most needed[15]. And each next-generation ViaSat-4 satellite will have 5-7 times that amount of capacity.

Viasat has also pioneered mobile broadband services using innovative antenna designs for earth stations in motion (ESIM) service to aircraft, ships and other land-based users. These services include gate-to-gate, port-to-port, high-speed broadband for communications and entertainment, cabin support, and fleet digitization for passengers and crew on aircrafts and ships. Managing NGSO interference into GSO networks is critical to ensure the continuing availability and reliability of these vital GSO services in South Africa. ICASA must protect these advanced GSO UHT networks to ensure continued availability, innovation and competition. Both GSO network and NGSO system operators need regulatory certainty for interference-free sharing of spectrum, including national spectrum access, to plan their operations and services for end users.

The potential for disruption to GSO networks by co-frequency NGSO systems is well-known and is what led to the development of NGSO system equivalent power flux density (EPFD) limits 20 years ago in some frequency bands (*See* Figure 7 below) based on then-existing NGSO and GSO system technologies and system designs.

Current ITU Radio Regulations (RR) for protection of GSO networks from NGSO systems are a patchwork, particularly in Ku and Ka bands as shown in Figure 7 below.

These provisions include:

a) RR No. 22.2 that requires *NGSO systems* not to cause **unacceptable interference** to, or claim protection from, GSO networks;

b) In certain frequency bands, a requirement that NGSO systems meet certain **equivalent power flux density (EPFD) limits**; and

[15] *See ViaSat-3 Satellite Constellation*, ViaSat, Inc., https://www.viasat.com/space-innovation/satellite-fleet/viasat-3/.

c) In other frequency bands, a requirement that NGSO systems coordinate under RR No. 9.11A based on ITU network filing **date priority**.

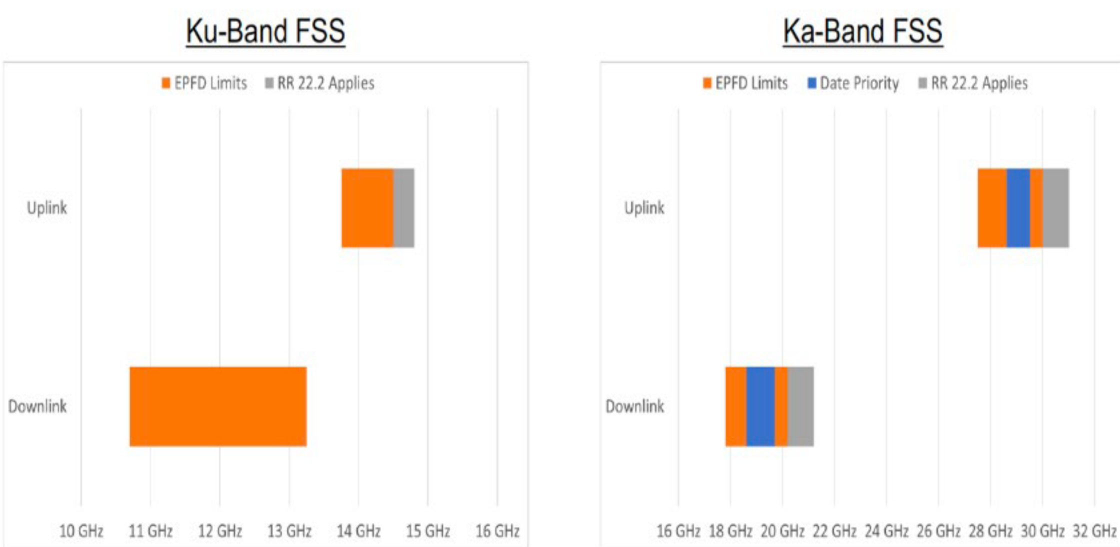

Figure 7: Patchwork of GSO protection rules for different bands.

As explained further in this section, the ITU EPFD framework and associated software do not account for the multiplying effect of several underlying NGSO system issues – (1) actual NGSO system operation may not be consistent with the inputs used for EPFD validation; (2) existing Rec. S.1503-2[16] software can wrongly estimate that an NGSO system may be able to comply with certain Article 22 limits at one location even though its operations can be expected to exceed relevant limits in other locations; and (3) the number and complexity of NGSO systems (and their constituent satellites) that contribute to GSO network interference are far greater than anticipated when the EPFD limits were established.

Both NGSO system and GSO network characteristics have evolved significantly over the last 20 years. NGSO system EPFD limits were largely finalized in 2003 at a time when a 288-satellite NGSO system was considered large and GSO networks were capable of achieving only relatively low throughput (*e.g.*, 1 Gbit/s). Today's NGSO systems include

[16] *See* ITU-R Recommendation 1503-2 (12/2013), "Functional description to be used in developing software tools for determining conformity of non-geostationary-satellite orbit fixed-satellite system networks with limits contained in Article 22 of the Radio Regulations", *superseded by* ITU-R Recommendation S.1503-3 (01/2018). The ITU EPFD compliance software has not been updated to reflect the changes from S.1503-3.

thousands, or tens of thousands, of satellites in a variety of low Earth orbits (altitudes and inclinations). Even if a GSO network earth station is in an area illuminated by a single NGSO satellite main beam, it will receive radiation from 100's (or often 1000's) of NGSO satellite system beam sidelobes. In addition, significant questions exist about how today's NGSO system operators will be able to both calculate and actually manage the *cumulative* interference impact of the countless sidelobes created by satellite antenna beams and the sidelobes and backlobes created by NGSO user terminals, as shown in Figure 8 below.

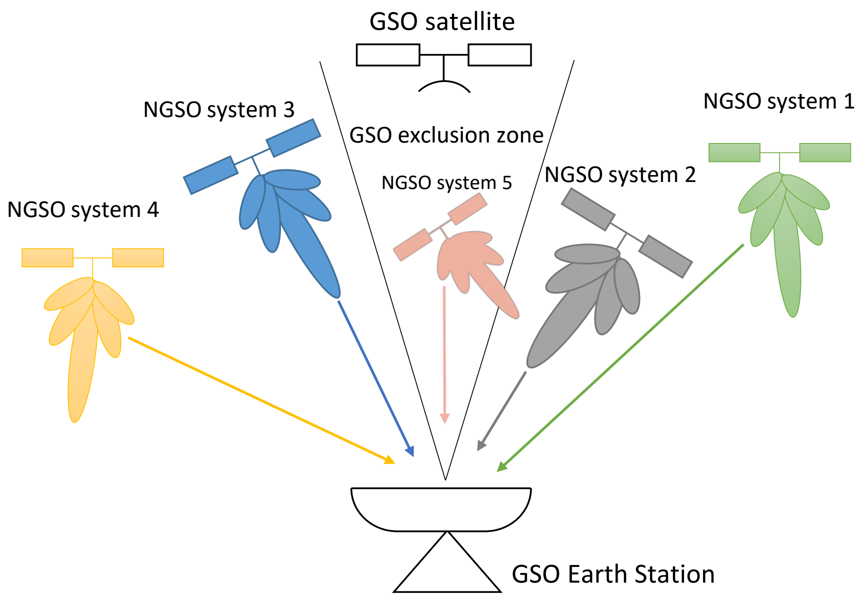

Figure 8: Interference received from mainlobe and sidelobes of numerous satellites of multiple NGSO systems.

Further, GSO networks are approaching a four-order-of-magnitude increase in capacity due in part to increased spectral efficiency which is facilitated by employing satellite receivers with low noise temperatures and high antenna gains (G/T). Today, even a single NGSO system has the potential to cause interference into GSO UHT networks. Multiple NGSO systems operating simultaneously pose an even greater risk to those GSO networks. If the NGSO communication links are not angularly separated from the GSO network arc by a sufficient angle, they could easily cause debilitating levels of service degradation and capacity losses to GSO networks.

Aggregate NGSO system uplink (Earth-to-space) EPFD limits do not exist. Without them, Figure 2 below shows that the NGSO system earth stations operating in the presence of an increasing number of NGSO systems can significantly degrade the service provided by advanced GSO satellites with highly efficient satellite receivers in space (high G/T).

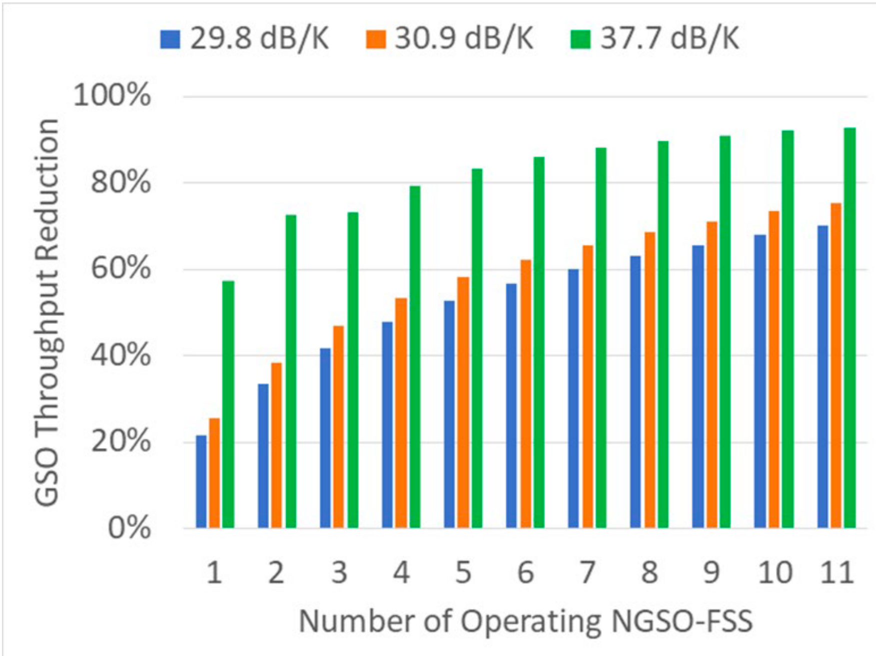

Figure 9: GSO throughput reduction with current EPFD up limit.

The G/T performances shown above correspond to GSO satellite networks that are on file at the ITU and are either already deployed or planned to be launched. The throughput reduction above has been calculated using the methodology in ITU-R Recommendation S.2131 to compute percentage of degraded throughput[17].

In addition, there are inadequacies in the ITU methodology used for EPFD examination which leads to false results and is open to misuse. At the ITU, at the coordination stage, there is a process for estimating whether a stated NGSO system design may be able to meet NGSO system EPFD limits specified in RR No. 22.5 at one location, even though it can be exceeded at another location. There are well-recognized flaws in the ITU-R Recommendation S.1503 validation algorithm and the associated software that yield false results.

[17] *See* ITU-R Recommendation S.2131-0 (09/2019), "Method for the determination of performance objectives for satellite hypothetical reference digital paths using adaptive coding and modulation".

Software based on ITU-R Recommendation S.1503-2, which is used by the ITU Radiocommunication Bureau to validate NGSO system filings, contains an algorithm to derive a 'worst case geometry', a location for the NGSO system being examined and a representative GSO network that is intended to represent the highest single-entry NGSO system EPFD level. Recommendation S.1503-2 includes an algorithm to calculate NGSO system EPFD levels only for that specific location and the corresponding GSO earth station and GSO satellite. The ITU Radiocommunication Bureau evaluates EPFD levels for the NGSO system filing only at that one location. Notably, the GSO earth station location used in the analysis is not the only location where ITU limits can be exceeded. Expected NGSO system EPFD at locations other than the location automatically calculated by the ITU software can exceed the applicable NGSO system EPFD limits. That is, an NGSO system can appear to satisfy an ITU EPFD examination even though it actually would exceed NGSO system EPFD limits and violate the Radio Regulations. This is because of a fundamental flaw in the ITU methodology and software that has been well-documented.

Examples of NGSO system EPFD violations due to flaws in ITU 1503-2 software are provided in the following analysis by OneWeb submitted to ITU-R Working Party 4A for an earth station located at Goonhilly, England[18] (Figures 10 and 11 below). This analysis addresses both Ku and Ka band downlink EPFD exceedances for STEAM-1 and STEAM-2B non-GSO FSS systems respectivelyThe blue line shows the single-entry EPFD limits from Article 22 (Table 22-1A) and the orange line is the actual levels of EPFD calculated at Goonhilly, England, a location like many others where EPFD exceedances are not identified because they are not tested by the flawed algorithm of ITU-R S.1503-2.

[18] *See* ITU-R Working Party 4A, Document 4A/[OW-4], (19 June, 2019), "Need for a Procedure to Deal with Cases of EPFD Exceedance that are Not Detected by the Worst-Case Geometry Algorithm in Recommendation ITU-R S.1503".

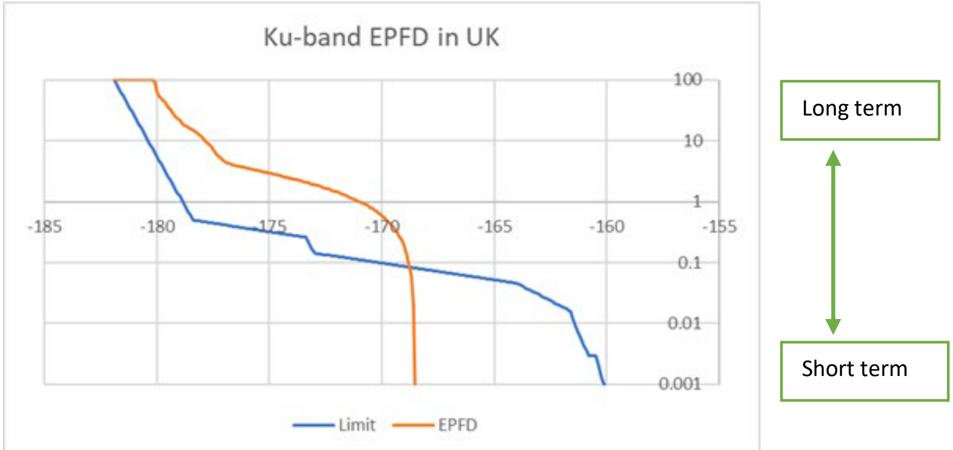

Figure 10: Goonhilly, England Ku band NGSO system EPFD exceedances not identified by ITU-R Rec. 1503 software.

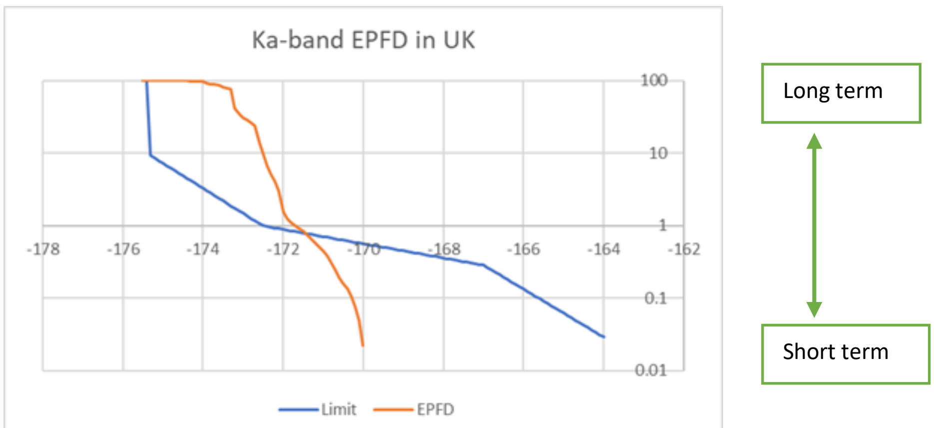

Figure 11: Goonhilly, England Ka band NGSO system EPFD exceedances not identified by ITU-R Rec. S.1503 software.

It can also be observed from above plots that, in the Ku band, the EPFD limits are exceeded for percentages from 0.1% to 100% of the time, by up to 8.5 dB[19]. An exceedance of this magnitude also means that this system uses up the entire allowance, and more, of EPFD that is permitted in the *aggregate* for multiple NGSO systems by ITU Resolution 76[20].

19 As demonstrated in the above Ku band EPFD plot at Goonhilly, England, the STEAM-1 NGSO system generates an EPFD level of -169.9 dB(W/m^2) for 0.5% of time. The single entry EPFD limit for the same percentage of time, according to Table 22-1A in RR, is -178.4 dB(W/m^2). This shows a *single entry* EPFD exceedance of 8.5 dB. The *aggregate* EPFD limit, according to Table 1A in Annex 1 to Resolution 76 for the same percentage of time, is -173 dB(W/m^2), which is also exceeded in this case by 3.1 dB.

20 ITU Radio Regulation, Resolution 76 (Rev. WRC-15), "Protection of geostationary fixed-satellite service and geostationary broadcasting-satellite service networks from the maximum aggregate equivalent power flux-density produced by multiple non-geostationary fixed-satellite service systems in frequency bands where equivalent power flux-density limits have been adopted".

In addition, NGSO operators are seeking to erode the protection provided to GSO networks by the Article 22 NGSO system EPFD limits by changing the "measuring stick" under ITU-R Recommendation S.1503. Any changes to ITU-R Recommendation S.1503 cannot be done in isolation but rather must address the overall effect and risk of interference to GSO networks by considering all of the known deficiencies in an outdated 20-year framework, such as the software flaw illustrated above. More fundamentally, South Africa should factor into its licensing rules that NGSO operators have the ability to submit inputs and assumptions that yield a validation result that will not be actually realized when the NGSO system is placed into operation.

Furthermore, some NGSO systems also are splitting their system into multiple ITU filings to impermissibly aggregate so-called "single entry" EPFD contributions in an attempt to generate more interference during operation than otherwise would be permitted for a single NGSO system. Some NGSO operators are operating a single NGSO system under filings made by multiple administrations for the same frequency bands, also in an attempt to generate more interference during operation than otherwise would be permitted for a single NGSO system (Figure 12 below).

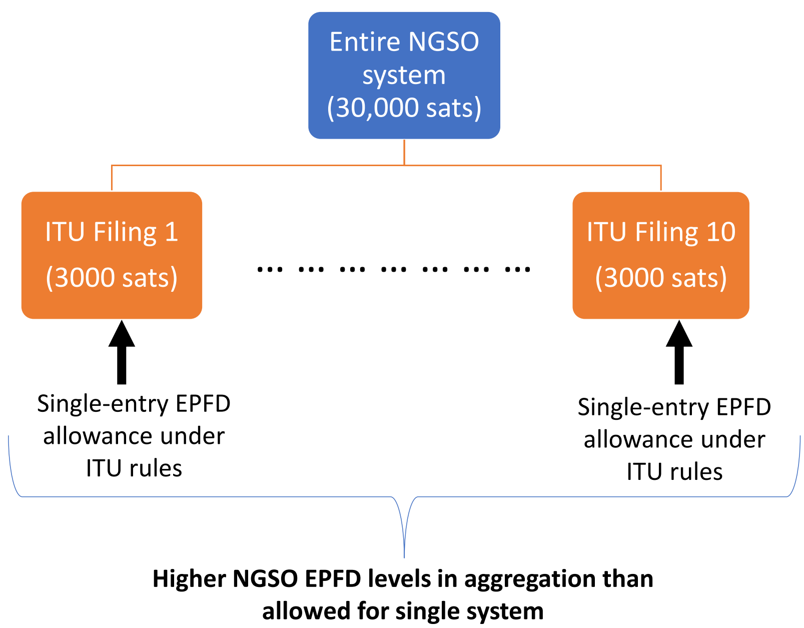

Figure 12: Single NGSO system split into multiple ITU filings to circumvent ITU Radio Regulations.

The issue of *aggregate* interference into a GSO network generated by the operation of multiple co-frequency NGSO systems also requires careful scrutiny by ICASA. As illustrated above in Figure 9, in the uplink direction, even a single NGSO constellation has the potential to cause unacceptable (and even harmful) interference into GSO networks, resulting in significant degradation and capacity losses for GSO networks that serve South Africa. Multiple NGSO systems operating simultaneously pose an even greater risk to GSO networks. This can significantly degrade the provision of critical GSO-based services in South Africa.

The same is true in the downlink direction. The single entry NGSO system EPFD limits in Article 22 were derived assuming only 3.5 NGSO systems operating simultaneously. As it stands, there are many more than 3.5 NGSO systems filed at the ITU today and a number of those NGSO systems are already being deployed. Resolution 76 provides aggregate EPFD↓ limits that must be applied in this case. In accordance with *resolves* 1 and 2 of Resolution 76, administrations are required to take all possible steps, including, if necessary, modifying NGSO system operations to ensure that aggregate NGSO system EPFD limits are not exceeded and in the event of exceedance, taking all necessary measures expeditiously to reduce the *aggregate* NGSO system EPFD levels.

It is critical to address and prevent the potential for aggregate interference into GSO networks from the operation of multiple NGSO systems that serve South Africa. It is also important for South Africa to ensure there is an effective mechanism in place so it can require NGSO operators serving South Africa to reduce transmissions across multiple NGSO systems to prevent such interference to other satellite systems and networks also serving South Africa. Viasat urges ICASA to address this issue as part of its processes for licensing NGSO systems to serve South Africa.

There are additional interference matters that are not assessed as part of the ITU's validation of an NGSO filing, and which require analysis at the national level and as part of South Africa's NGSO system license review process, *prior* to any grant of authority to serve the country. Namely, the ITU does not conduct a compliance check against "operational" and "additional operational" NGSO system EPFD limits which must be met to fulfil NGSO system obligations under the ITU Radio Regulations. The "operational" and "additional operational" NGSO system EPFD limits protect GSO networks from synchronization loss, which can cause extended periods of service outage, as a result of high levels of interference from NGSO systems for a short period of time. A commitment from NGSO operators to meet the "operational" and "additional operational" EPFD limits without any evidence or analysis that they actually can do so has the potential to cause adverse impacts on GSO network services and South African users. Again, the regulatory examination of ITU filings that the ITU conducts under RR Nos. 9.35 and 11.31 with respect to the single entry EPFD limits in the ITU Radio Regulations, Tables 22-1A-E, 22-2 and 22-3 *simply does not address this issue.*

Aside from the above issues with the NGSO system EPFD limits framework and the flawed evaluation process described above, those provisions apply only in certain shared bands and not others, as depicted above in Figure 2.

More specifically, the NGSO system EPFD limits do not apply in certain frequency bands *e.g.*, 20.2-21.2 GHz and 30-31 GHz. In these bands, ITU RR Article No. 22.2 prohibits 'unacceptable interference' from *any* NGSO system. Therefore, ICASA must apply appropriate conditions to protect GSO networks for the potential of receiving unacceptable interference from NGSO systems that serve South Africa.

Other portions of Ka band, for example, the 28.6-29.5 GHz and 18.8-19.7 GHz bands, are subject to coordination between NGSO systems and GSO networks under Article 9 of the ITU Radio Regulations, with later-filed NGSO systems bearing the obligation not to cause more interference than specified in various ITU-R Recommendations. For example, in the case of uplink (Earth-to-space) NGSO system interference into GSO satellite receivers in space, the levels in Figure 3 would be not only unacceptable but also harmful and warrant specific measures to be taken when considering any request for authority to serve South Africa by an NGSO system.

In the frequency bands where EPFD limits do apply, since the calculation of NGSO system EPFD levels and compliance with those limits is based on complex models and simulations, it is necessary to ascertain whether the models and simulation represent actual operations of NGSO systems as they are deployed. Viasat urges ICASA to not solely rely on ITU-R Recommendation S.1503 software to assess the interference environment created by NGSO systems. Software-based EPFD examination through the ITU process is only as accurate as the inputs provided by NGSO operators. In order to generate meaningful and accurate NGSO system output EPFD levels, at the South African license application and modification stages, inputs like actual orbital characteristics, operational parameters, EIRP and PFD masks need to be provided by the applicant and closely examined for their validity and consistency with respect to the technical characteristics and operation of NGSO systems. For example, it is important for national regulators like ICASA to require that NGSO operators provide appropriate and necessary information and demonstrate at the South African license application and modification stages how their systems, specifically those that implement phased arrays, will meet the EIRP and PFD input masks they provide for EPFD evaluation considering off-axis performance of the antennas across all steering angles, planes and geometries.

While ITU-R recommendations have been developed to assist administrations in measuring aggregate EPFD↓, they are not effective in measuring single entrant EPFD↓ once multiple systems have become operational, as it is impossible to differentiate between emissions from the individual systems. Hence, there is no possibility of directly measuring single entrant EPFD↓. The same applies to single entrant EPFD↑ measurements. Neither can be measured, they can only be calculated. The formula for doing so in provided in RR 22.5C.1, per RR 22.5D.1, the same formula is used for both EPFD↓ and EPFD↑.

The deficiencies in the existing framework to protect GSO networks from interference from NGSO systems are summarized in Figure 13.

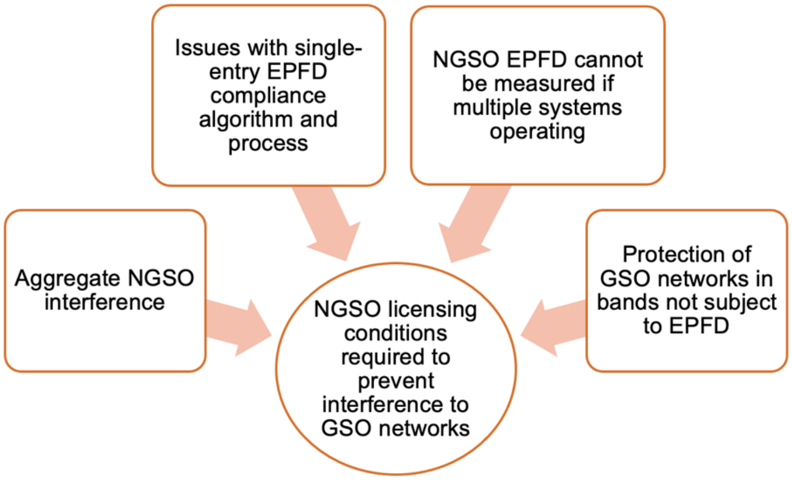

Figure 13: Known deficiencies in existing framework to protect GSO networks from NGSO interference.

In order to mitigate the risk of interference to GSO networks licensed by or serving South Africa, it therefore is critical to address this threat at the licensing stage, rather than hoping it can be addressed after NGSO operations commence. Viasat therefore recommends that ICASA address its responsibility for preventing radio interference by (i) analyzing and modelling the proposed NGSO systems' operating parameters based on their actual satellite network designs, gateways, and user terminal technology per the application and authorization requirements described below, and (ii) conditioning any grants of authority appropriately.

1. ICASA must require that NGSO systems serving South Africa maintain suitable "angular separation" or "avoidance" from the GSO arc, consistent with NGSO system ITU filings, with the separation angle depending on particular attributes of the NGSO system and GSO networks. GSO arc avoidance is a mitigation technique used by NGSO systems to protect GSO networks and can be defined as a non-operating zone in the field of view of a NGSO system satellite (see depiction below in Figure 3). Such angular separation must be maintained with respect to *all* frequency bands that the NGSO system applicant intends to use that are shared with GSO networks. It is important to note that angular separation imposes virtually no constraint on NGSO system capacity as large NGSO systems always have multiple options for assigning different satellites to serve different

locations on the Earth. Also, angular separation is routinely used and accepted in ITU coordination agreements to protect GSO networks from NGSO-generated interference.

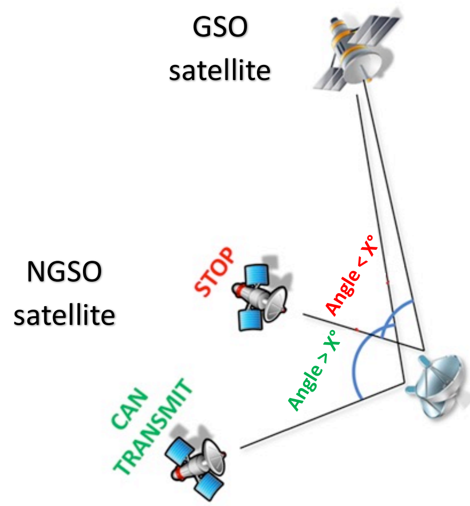

Figure 14: GSO avoidance angle.

2. If, despite measures being taken by an NGSO system licensee, interference into GSO network occurs, the obligation to assess and resolve any such interference should be placed on the NGSO systems and the interference could be addressed in a variety of ways (*e.g.*, increasing angular separation, reducing power, shaping antenna beams differently).

3. All applications for NGSO licenses must be analyzed by ICASA, as a whole, single system, even if they are operated under, or are comprised of, multiple ITU filings, including filings from different administrations. A single NGSO system should not be allowed to consume more than the interference allowance for a single NGSO system.

4. ICASA also should address the *aggregate* interference impact on GSO networks serving South Africa from multiple NGSO systems that are considered for licenses. For downlink aggregate EPFD, this can be done by assessing compliance with aggregate EPFD (down) limits. Until aggregate uplink aggregate EPFD limits are developed, ICASA should

apply an appropriate aggregate interference threshold (*e.g.*, ITU-R S.1323)[21] to be met collectively by all NGSO systems that serve South Africa.

5. If there is an aggregate interference problem, then the burden to resolve the interference must be equitably apportioned among *all* NGSO operators that serve South Africa.

NGSO-NGSO Spectrum and Orbital Sharing

Another concern is how unconstrained low earth orbit ("LEO") mega-constellations can consume significant portions of the look angles toward space, and essential LEO orbits, preventing use of the sharing tools that have been employed successfully for decades among NGSO systems.

This threat to NGSO spectrum sharing arises because LEO mega-constellations will "blanket the sky," causing many in-line interference events limiting and sometimes completely blocking other NGSO systems from sharing the same spectrum. LEO mega-constellations will rarely experience this problem themselves because their far greater number of satellites that block spectrum use by smaller NGSO constellations provides them with alternative communications paths where the same spectrum remains available to the mega-constellation. Such preclusive effects of certain large LEO constellations can be easily demonstrated with the charts below. At a given (static) moment in time, it may appear that certain "look angles" from a location on Earth are available (Figure 15), but over a mere 5 minutes, it is apparent that it is virtually impossible to find available look angles any longer (Figure 16).

21 *See* ITU-R Recommendation S.1323-2 (2002), "Maximum permissible levels of interference in a satellite network (GSO/FSS; non-GSO/FSS; non-GSO/MSS feeder links)* in the fixed-satellite service caused by other codirectional FSS networks below 30 GHz". (* The methodologies for determination of short-term interference criteria contained in this Recommendation are intended to address interference to GSO/FSS, non-GSO/FSS and non-GSO/MSS feeder links. However, the applicability of these methodologies for all such networks requires further verification).

Even if only one satellite (red dot) is allowed to serve a particular location, the mere possibility of that constellation's using any other satellites at the same time blocks look angles and prevents other NGSO operators to use the same spectrum. Even for the static case, it is difficult to find "look angles" because for every dot in the Figure 15 which represent satellites of the large LEO constellation, one must consider a preclusion zone around it created by an angular separation that is needed to avoid interference. It is thus easy to see how an operator of a single large LEO constellation could, in fact, monopolize virtually all the available spectrum resources.

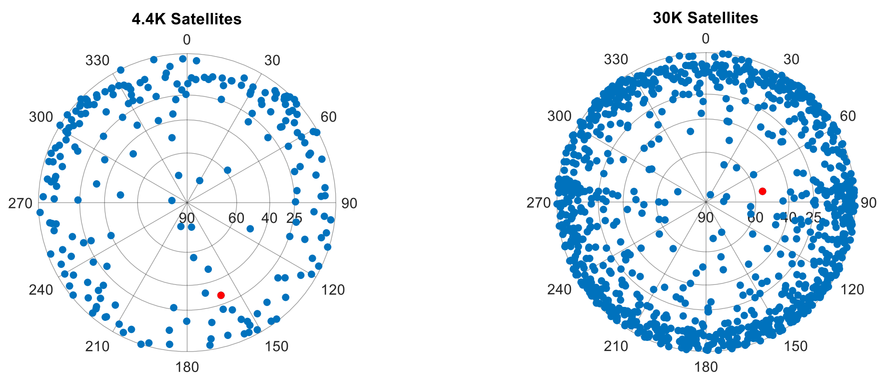

Figure 15: Satellites in view from a given location.

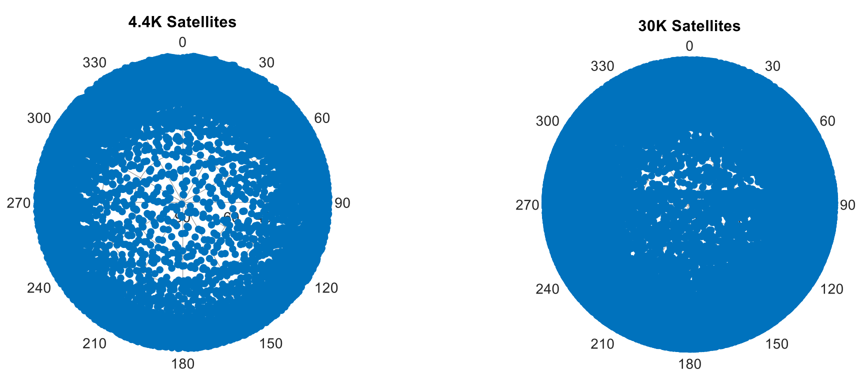

Figure 16: Satellite positions over 5 minutes: 4,400 satellites and 30,000 satellites on orbit.

This dynamic has the perverse effect of incentivizing a race in which LEO mega-constellations deploy many more satellites than are actually needed, utilizing large numbers of spectrally-inefficient satellites, and rejecting reasonable approaches that otherwise would enable spectrum sharing among all NGSO system types – even those operating at other altitudes.

The threat to orbital sharing exists because LEO orbits are limited, and LEO mega-constellation operators are in a race to populate a wide swath of the “best” orbits (in the 300 km to 650 km range) with huge numbers of satellites. And LEO mega-constellations are doing so by planning to operate with unnecessarily wide orbital tolerances, and thus would effectively fill up hundreds of kilometers of orbits to the exclusion of other NGSO systems that otherwise could operate alongside them. Particularly when LEO mega-constellations already must operate with much greater precision to avoid collisions, there is no good reason to allow LEO mega-constellations to provide service utilizing overlapping shells of satellites in very wide orbits that unduly consume what other otherwise would be shared.

Viasat recommends that ICASA adopt rules for market access that ensure equitable access to the same spectrum by multiple NGSOs, ensure equitable access to shared and limited NGSO and orbits, and ensure that NGSOs do not constrain access to the spectrum shared with GSO networks by causing undue interference.

The approaches and requirements proposed above to deal with the NGSO system interference threats will alleviate interference problems for ICASA that are almost certain to otherwise occur given the deficiencies and inadequacies of the existing (and outdated) ITU regime for NGSO system protection of GSO networks and multiple NGSO systems.

In conclusion, Viasat supports ICASA on its efforts to facilitate the deployment of satellite broadband, including ESIM, in South Africa and urges ICASA to preserve the entire 28 GHz spectrum for satellite broadband services. Viasat also supports identification of spectrum for terrestrial IMT/5G in the 26 GHz band, and other bands identified for terrestrial IMT/5G by WRC-19, while keeping critical satellite spectrum available for broadband service in South Africa. Viasat also urges ICASA to ensure (i) protection of GSO networks from interference created by NGSO constellations, and (ii) that shared radio frequencies and associated orbits are used rationally, efficiently and economically by multiple NGSOs, and that all NGSOs have equitable access to those orbits and frequencies.

Viasat appreciates ICASA's consideration of the information above. We remain at ready to answer any further questions or provide further details as requested.

Respectfully Submitted,

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Viasat