



9 July 2019

Ms. Aileen Chia
Director-General (Telecoms and Post)
Deputy CE (Policy, Regulation & Competition Development)
Infocomm Media Development Authority
10 Pasir Panjang Road
#03-01 Mapletree Business City
Singapore 117438

Submitted via email: Consultation@imda.gov.sg

Re: Second Consultation on 5G Mobile Services and Networks (7 May 2019)

Dear Ms. Chia,

Viasat appreciates the opportunity to comment on IMDA's Second Consultation on 5G Mobile Services and Networks ("Second 5G Consultation"). As IMDA acknowledges in the Second 5G Consultation, Viasat filed comments in the First 5G Consultation in 2017. At that time, Viasat explained the critical and extensive use it makes of the Ka Band, including the 28 GHz band (and its paired 18 GHz band), for its satellite fleet. Viasat also explained its plans for the now launched Viasat 2 satellite further increasing broadband speeds and coverage resulting in greater capacity for video streaming on airplanes, ships and vehicles, as well as in homes and communities to meet the growing demand for satellite broadband anywhere, especially in places where it has not been affordable. To this end, Viasat also works with partners around the world in places like Europe, Australia, and Brazil to expand affordable satellite broadband to fixed and mobile consumers and will continue to do so in other regions as the next generation of satellites comes online, including in Asia-Pacific.

As Viasat also explained in its previously filed 2017 comments, the next generation of its very high-throughput satellites, the ViaSat-3 global geostationary constellation, is planned to be in service around the world by 2022. The first two satellites will cover the Americas, Europe/Middle-East/Africa, and the third satellite, announced in February 2019, will provide broadband services throughout the Asia-Pacific region, including Singapore, providing ViaSat-3 class service with global coverage (See, Attached Appendix A for a full description of the Viasat 3 constellation). Viasat announced in February 2019 that it had ordered this third ViaSat-3 satellite for service with Asia-Pacific coverage (ViaSat-3 APAC),¹ which will complete the initial

¹ See, <https://corpblog.viasat.com/viasats-global-satellite-constellation-well-on-its-way-to-completion/>.



phase of Viasat's global constellation of ViaSat-3 class satellites. The satellites are geostationary and operate across the entire 27.5-29.5 or (28 GHz) uplink band and corresponding 17.7-19.7 GHz (18 GHz) downlink band, as well as adjacent parts of the Ka band. The satellites are designed to use the entire 28 GHz band in order to maximize service capabilities for equatorial regions as well as all other areas within their fields of view.

Viasat has also filed for a Ka band Non-Geostationary Satellite Orbit (NGSO) constellation that would serve the entire globe (ViaSat NGSO). It will consist of 20 satellites in four Medium Earth Orbit orbital planes at 8,200 kilometers altitude, with five satellites per orbital plane. The ViaSat NGSO system will operate across the 28 GHz and 18 GHz bands as well.

Viasat's 28 GHz broadband satellites support the following services:

- Government (civil, defence, intelligence, cyber, border protection, and national security)
- Enterprise
- Residential
- Aviation
 - Commercial passenger connectivity (<https://viasat.com.mx/in-flight-wi-fi/?lang=en>)
 - Business Air (<https://go.viasat.com/ms-ba-home.html>)
 - Crew, Cockpit, Flight Operations, and Aircraft Maintenance (<http://www.arconics.com/>)
- Maritime businesses
- Satellite-Powered WiFi services (<https://viasat.com.mx/community-wi-fi/?lang=en>; <https://www.viasat.com/news/viasat-introduces-viasat-urban-wi-fi-fastest-satellite-enabled-broadband-service-urban-areas>).

As noted above, the Viasat Geostationary and Non-Geostationary constellations use the entire 28 GHz band. To meet the rapidly expanding consumer demand for satellite-powered global high speed broadband services, it is necessary to use the entire Ka band spectrum, just like demand for terrestrial systems requires access to adequate spectrum to meet demand. Viasat has been able to produce the highest throughput satellites ever built by utilising spot beams re-using spectrum efficiently and repeatedly. By taking a holistic approach to the design of the architecture, and basing its design on Geostationary satellites located directly over the equator, Viasat has maximized its ability to serve that region. If the band is segmented it reduces the spectrum available and the overall capacity, and thus affects the cost effectiveness of a satellite network, and thus the price of services to end users.

When satellite operators first began providing Internet services about 20 years ago, they tried to adapt their existing satellites - which were designed to serve low data rate user terminals (VSATs) or distribute video content over a large geographic area - to providing Internet services. Since the satellites they were using were not designed for this purpose, the resulting service was considered slow and expensive compared to terrestrial alternatives.

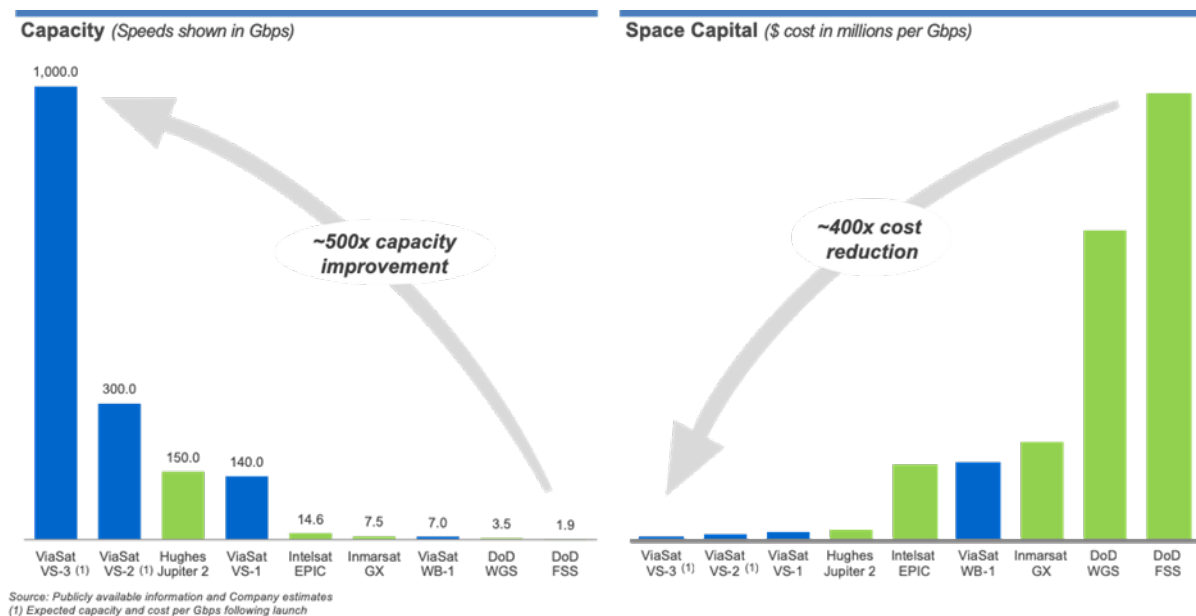


Figure 1 - Revolutionary change in economics of satellite broadband services

As shown in Figure 1 above, all this has changed in recent years with the design and launch of a new generation of Very High Throughput Satellites (VHTS) that have been specifically designed to provide high quality broadband connectivity. A geostationary satellite – whether it be for C band video distribution or a VHTS satellite - costs roughly the same amount to design, build and place in orbit – roughly \$300-\$500 million.

Whereas traditional C and Ku band satellites could provide at most a few Gbit/s of capacity, each ViaSat-3 satellite will have over 1 Terabit/s of capacity, allowing the cost per bit to be radically reduced, resulting in more affordable service for the end user. This is enabled by access to the full Ka band. Over the past 10 years, the capacity of satellites has undergone a revolution: increasing about 500 times and resulting in a 400 times reduction in the cost per bit. For the first time, satellite services provided over a ViaSat-3 satellite will have similar performance and cost to terrestrial services.



Just like terrestrial systems, reduced capacity because of artificial spectrum constraints would increase the cost of the available bandwidth and leave untapped satellite broadband capabilities for consumers. Also, due to the ViaSat-3 satellite network design, capacity can be dynamically focused on areas where and when it is needed. For example, over major airline hubs and maritime ports, like Singapore, when additional capacity is needed. Other examples would be for major defence training and operations and homeland and national security requirements.

As explained above, Viasat has continued to invest in Ka band satellites and expand the use of all of the Ka band frequencies, including the 28 and 18 GHz bands, to bring affordable broadband to fixed and mobile consumers. As Viasat gets closer to the launch and operation of the ViaSat-3 constellation, it is critical that countries where Viasat's transformative broadband services will be used, like Singapore, ensure that spectrum is available to meet consumer demand for these services.

I. The 28 GHz Band is for Satellite Broadband

Viasat focuses the following comments on the mmWave portion of the IMDA Second 5G Consultation. First, it is important to state that as a technology leader Viasat supports the development of new technologies, including 5G, both terrestrial and satellite, as part of the 5G ecosystem (See, Appendix B, *Satellite in the 5G Ecosystem*). In this regard, it is important to note that 5G advances are not unique to terrestrial networks. In fact, satellite broadband is already using many of these advances and has been doing so for many years. These 5G type advances include use of low latency radio interfaces (e.g., Satellite-Powered WiFi), network slicing, and edge computing or caching.

Second, it is also important to keep in mind the limitations that terrestrial 5G deployment may face in the mmWave bands, as acknowledge by IMDA in the Second 5G Consultation. For example, early rollouts of terrestrial mmWave 5G networks are proving to be more challenging than originally anticipated. There have been several recent developments in the deployment of both fixed and mobile terrestrial wireless broadband services that are important for IMDA to consider as part of this consultation and for determining the best use of the 28 GHz band spectrum.

On the fixed side, there have been recent studies on the initial deployment of fixed wireless services in the 28 GHz band. MoffettNathanson, a respected independent research firm, recently published a report titled "Fixed Wireless Broadband: A Peek Behind the Curtain of Verizon's 5G Rollout". This report finds that 5G deployment costs are much higher than initially



expected and 5G penetration rates lower due to a variety of potential factors, but importantly linked to the much smaller cell radii than in lower frequency bands.² On the mobile side, Intel has decided not to enter the mobile modem business because, according to their CEO, "[i]t has become apparent that there is no clear path to profitability and positive returns," Intel leader Bob Swan said in a statement.³

Third, it is important to note that, global momentum is for *expanded satellite use* of the 28 GHz band for fixed and mobile satellite broadband services worldwide, not for terrestrial 5G. This is essentially the same circumstance as at the time of the final decision at WRC-15. Most countries are following the WRC-15 decision and oppose any terrestrial 5G in the 28 GHz band. For example, the CEPT Roadmap for 5G, covering 48 members states, provides that the 28 GHz band is for satellite broadband, including aeronautical connectivity, and not for terrestrial 5G. Other regions, including the RCC and Arab Spectrum Management Group, also oppose introducing 5G into 28 GHz band. China, Brazil, India and Australia have all also recognized the importance of preserving the 28 GHz band for existing satellite broadband services. In addition, recently African countries, represented by their main sub-regional groups, support expanding satellite use of the 28 GHz band, not terrestrial 5G. All told, the number of countries supporting satellite use of the 28 GHz band is over 120, and growing.

Many satellite investment and deployment decisions have been made based on the vast majority of countries deciding that the 28 GHz band is for current and rapidly expanding satellite broadband requirements. Just like terrestrial systems, reduced capacity because of artificial spectrum constraints will increase the cost of the available bandwidth and leave untapped satellite broadband capabilities for consumers in countries that decide not to follow the world community.

II. The 26 GHz Band is a Good Band for Terrestrial 5G Deployment

The 26 GHz band looks like a much more promising band for terrestrial 5G than the 28 GHz band due to international support and the light deployment in the band. Based on the IMDA proposed mmWave deployment plan, as an add-on to the lower band licenses, the 26 GHz band can easily accommodate multiple 5G operators. There is no need to accommodate

² <https://venturebeat.com/2019/03/22/report-verizon-5g-home-service-too-expensive-to-scale-attracts-few-users/>

³ [Intel says it will exit the 5G phone business as Apple and Qualcomm strike multiyear deal, The Verge, 16 April 2019.](#)



terrestrial 5G within the 28 GHz band. This is especially true given the IMDA finding that there is excess spectrum supply in the 26 GHz band alone.⁴

In this respect, Viasat notes that any desire to accommodate mmWave 5G should be able to be fulfilled using the *entire 3.25 GHz of the 26 GHz band (24.25-27.5 GHz)* for terrestrial 5G systems that are designed in accordance with 3GPP standards and otherwise using good engineering techniques, including employing the latest filtering technology optimized for whatever protection level is adopted for the earth exploration satellite service (EESS) operating below 24 GHz. It is expected that there will soon be additional independently-developed information made available to IMDA to explain this significant technical development.

III. IMDA Can Have Both Terrestrial 5G and Fixed and Mobile Satellite Broadband

Viasat agrees with IMDA view that mmWave bands are only likely to see limited 5G terrestrial deployment given propagation characteristics of the bands. On the other hand, there is already growing satellite broadband use and additional investment in the full 28 GHz band, not just the upper part of the band. As requested by WRC-15 in Agenda Item 1.5 (Earth Stations in Motion or ESIMs) for the 27.5-29.5 and 17.7-19.7 GHz paired satellite frequency bands, the international community is moving forward to expand the use of the full 28 GHz band for ESIMs use with geostationary satellite networks, like ViaSat-3. There is also growing demand for non-geostationary (NGSO) fixed and mobile use of the 28 GHz band and the paired 18 GHz band.

Viasat appreciates IMDA's acknowledgement of satellite use of the bands for expanding port-to-port and gate-to-gate maritime and aviation satellite broadband, respectively. The reality is that satellite broadband, just like terrestrial networks are facing extensive demands from end user customers in both of these industries. In addition, land mobile industries, like trains, buses and other vehicles, like cars, are becoming heavier users of mobile satellite broadband services as well and these markets are expected to grow rapidly. This is in addition to expanding fixed broadband satellite use in the 28 GHz band around the globe (e.g., Community and Urban WiFi).

On the other hand, the 26 GHz band is an excellent band for terrestrial 5G deployment and offers over 3.25 gigahertz of spectrum. This is more than enough spectrum to accommodate the package add-on requirements that IMDA contemplates for terrestrial 5G in the Second 5G Consultation. Therefore, in recognition of the vast amount of spectrum available in the 26 GHz band for terrestrial 5G deployment and the desire of

⁴ See, Second 5G Consultation at para. 123.



the international community for expansion of satellite broadband in the 28 GHz band, Viasat respectfully requests that IMDA consider expanding satellite allocations throughout the 28 GHz band and offer terrestrial package spectrum for 5G in the 26 GHz band. This approach allows both services to flourish and is consistent with the direction of the international community and technology developments in each band. In addition, Viasat appreciates IMDA's acknowledgement of the need to look at refarming options for terrestrial 5G in the low and mid bands. This should be done instead of considering making any spectrum in the 28 GHz band available for 5G.

Again, Viasat appreciates the opportunity to provide comments in this Second 5G Consultation and remains ready to respond to any additional questions from the IMDA.

Sincerely,

A handwritten signature in black ink, appearing to read "CJ Murphy", is written in a cursive style.

Christopher J. Murphy
Associate General Counsel
Regulatory Affairs



IMDA Second 5G Consultation Questions & Viasat Responses

Question 1: IMDA would like to seek the industry's views on skills requirements and the potential job demands in the future of networks and next generation of application/use-cases with 5G technology.

Viasat Response: As explained above, the satellite industry has been incorporating many of the 5G network components (e.g., digitization, advanced network architecture, satellite-powered hybrid networks, global mobility, network slicing). As a global leader in technology, including aerospace and maritime, Singapore is well positioned to take advantage of the advances in satellite fixed and mobile broadband communications. Therefore, Singapore is poised to be a beneficiary of the 5G ecosystem, including for satellite broadband fixed and especially mobile technology both directly and indirectly as a major hub for the aviation and maritime industries.

Question 2: IMDA would like to seek views on:

i) The types of innovative use-cases that could capitalise and further enhance Singapore's competitive advantages, trigger new growth potential and/or strengthen Singapore's existing strategic pillars; and

ii) Areas of government support that the industry require in order to enable innovation and development in 5G.

Viasat Response: As an aviation and maritime hub in Asia-Pacific, Singapore is a natural location for both gate-to-gate and port-to-port satellite broadband communications, respectively. It should be noted that the International Maritime Organization (IMO) is supporting the expansion of ESIMs through WRC Agenda Item 1.5 in the 28 GHz band. Singapore supporting ESIMs at WRC-19 is welcome and appropriate given its major role in both of these industries. Viasat also suggests that Singapore can maintain its international leadership in these industries and still satisfy the requirements of terrestrial 5G in the other bands identified above, including the 26 GHz mmWave band.

Question 3: IMDA would like to seek views and comments on the suitable technical parameters, including the reasonable amount of guard band needed to reduce potential interference between IMT and FSS use in the 3.5 GHz band.

Viasat Response: Viasat does not take a position on this question.

Question 4: IMDA would like to seek views and comments on the following:

i) Whether the industry agrees with the timelines on the expected availability of the next wave of 5G spectrum; and

ii) Whether current deployments in the 2.5 GHz FDD spectrum band (based on 3GPP Band 7) and in the 2.5 GHz TDD spectrum band (based on 3GPP Band 38), should be refarmed to 3GPP Band 41 for future 5G services in Singapore, and the views on the associated cost and challenges.

Viasat Response: Viasat does not take a position on this question.

Question 5: IMDA would like to seek views, comments and suggestions on:

i) Whether Singapore should have two nationwide networks as a start given the considerations and trade-offs;

ii) The proposed 3.5 GHz lot sizes and spectrum packages;

iii) Whether 5G equipment would be able to support 3.5 GHz bandwidths in multiples of 50 MHz;

iv) The value, if any, in assigning the remaining 50 MHz restricted 3.5 GHz spectrum in the same assignment exercise as the unrestricted lots;

v) The proposed mmWave lot sizes and preferred band plan option; and

vi) The rank order preference of the 3.5 GHz spectrum package and mmWave lot combinations.

Viasat Response: Viasat urges IMDA to authorize terrestrial 5G in the 26 GHz band of the mmWave spectrum and not the 28 GHz band, as addressed above.

Question 6: IMDA would like to seek views, comments and suggestions on:

i) The proposed network rollout and performance obligations to be imposed on the spectrum right holders;

ii) The methodology and measurement criteria for the coverage obligation;

iii) The network design and resilience challenges of 5G (in particular, enabling technologies, such as SDN, NFV and Cloud Computing that may fundamentally change how the network would be designed and deployed) and possible measures to address them, and whether there are other aspects that should be considered to enable trusted and resilient 5G network; and

iv) The framework for the provision of 5G wholesale services.

Viasat Response: Viasat suggests that any IMDA authorization of terrestrial 5G ensure conditions, include regulatory measures and obligations, to ensure that satellite services can be deployed on an unencumbered basis as part of any authorization of terrestrial 5G in the mmWave bands.

Question 7: IMDA would like to seek views, comments and suggestions on the spectrum assignment framework, including:

i) The proposed assignment approach;

ii) The spectrum right duration of the 3.5 GHz package and mmWave lots;

iii) The evaluation criteria, sub-criteria and weights to assess the proposals;

iv) The assessment methodology, including evidence (documentary or otherwise) to evaluate the proposals; and

v) The enforcement and/or audit mechanisms to ensure that applicants are able to deliver on their proposals.

Viasat Response: Viasat does not take a position on this question.

Question 8: IMDA would like to seek views and comments on the trade-offs (particularly on resilience, 5G capabilities) and technical feasibility of the various levels of infrastructure sharing.

Viasat Response: Viasat does not take a position on this question.

Question 9: IMDA would like to seek views and comments on the following:

i) The synchronisation approach for 5G TDD networks in a multi-operator environment for the 3.5 GHz and mmWave bands, specifically for the following:

a. Synchronised networks: the required frame alignment, compatible frame structures and BEM specifications for AAS and non-AAS base stations; and

a. Unsynchronised networks: the amount of guard band, geographical separation and BEM specifications for AAS and non-AAS base stations;

ii) The adoption of other suitable mitigation measures to mitigate interference between unsynchronised networks; and

iii) The need for IMDA to mandate a regulatory requirement for synchronisation across the 5G TDD networks or leave it to operators to co-ordinate their network deployment and parameters in order to reduce interference between networks.

Viasat Response: Viasat does not take a position on this question.

Question 10: IMDA would like to seek views and comments on the following:

i) The interest from industry players to leverage 5G spectrum or other mobile spectrum bands for fixed-wireless services that support mobile connectivity; and

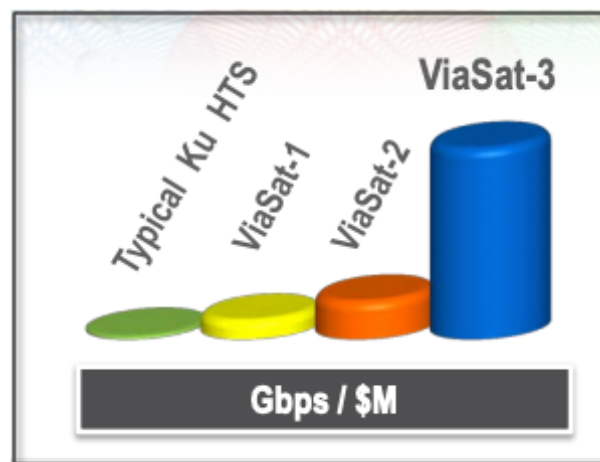
ii) The policies (e.g., spectrum allocation, numbering) that should be considered to facilitate such use-cases.

Viasat Response: Viasat's main point in these comments is that IMDA does not have to choose between having the most advanced 28 GHz satellite broadband services and accommodating terrestrial 5G. Both services can and should be accommodated in separate bands.

ANNEX A

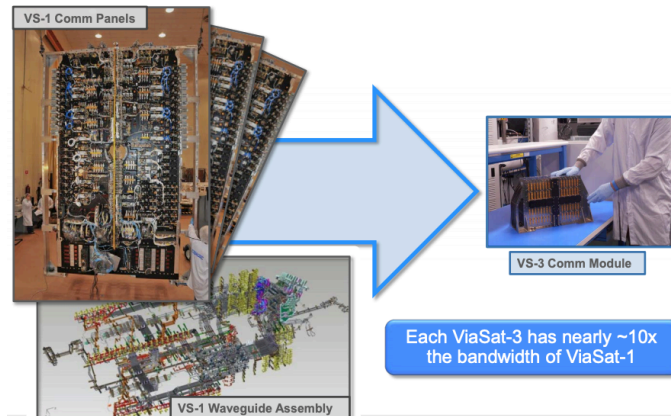
Description of ViaSat-3 Constellation

Viasat has a long history of innovation in satellite technologies and is a leading provider of communications solutions to businesses, consumers and government users. Viasat has a proven ability to successfully deploy new satellite technologies that it develops, including groundbreaking capabilities that reduce the “cost per bit” of delivering satellite broadband service, making it possible to provide reliable high-speed broadband connections that are comparable to what consumers have come to expect for terrestrial broadband services, at competitive prices. Viasat’s first-generation broadband satellite, ViaSat-1, supports maximum throughput of approximately 140 Gbit/s. When ViaSat-1 commenced operations in 2012, it had more than 14 times the throughput of any other Ka-band satellite in orbit at that time. Viasat’s second-generation high-capacity satellite provides approximately 260 Gbit/s of capacity. With each evolutionary step of Viasat’s satellite technology, the bandwidth economics improve because of the significantly greater capacity Viasat has enabled on a single spacecraft.

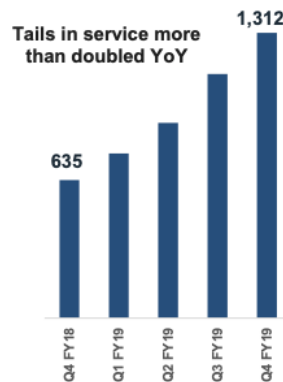


In turn, the ViaSat-3-class design represents the next giant leap forward in broadband satellite capabilities, with unprecedented capacity, service speed and flexibility for a satellite platform. With over 1 terabit per second of capacity, this satellite will offer over four times the throughput of the best performing satellite in the marketplace today (ViaSat-2), and approximately five times that of the next highest-throughput Ka-band satellite currently in orbit (Jupiter 2). The service area of this ViaSat-3-class design covers approximately one-third of the Earth’s surface—about four times the coverage of ViaSat-2. In addition, the ViaSat-3-class design supports even more individual users with 100 Mbit/s service (and up to 1 Gbit/s) anywhere within the service area. And through its ability to dynamically direct capacity to where customers and demand are located, the satellite can extend capacity and coverage where

and when it is most needed. One of the key advances that has led to these developments and enabled these capabilities is the ability to substantially reduce the size and mass of the communications modules on the spacecraft, as depicted in the figure below.

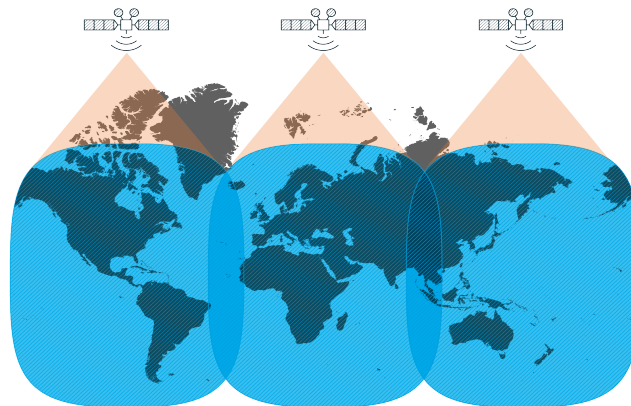


The ViaSat-3-class design provides far greater bandwidth economics than any other satellite in operation today and will enable the provision of services and the offer of service terms never before possible. These unparalleled capabilities are critical to bridging the digital divide and increasing the availability and affordability of high-quality, high-speed connectivity for unserved and underserved communities: areas without cost-effective alternatives or where services with only slower speeds are available. Moreover, the capacity of the satellite allows it to satisfy the demand for satellite-powered broadband services that are growing exponentially, as people increasingly demand high-speed service in mobile settings—on airplanes, trains, buses, cars, trucks, helicopters, ambulances, and ships alike. Today, Viasat provides over 150 million connections annually to personal electronic devices on just 1,312 commercial aircraft, a number that has more than doubled in the past year.



Viasat expects to install in-flight connectivity systems on an additional 490 aircraft under existing contracts, which, once completed, will put Viasat closer to the mark of 2,000 in-service

aircraft. Projections indicate that there will be hundreds of millions of personal electronic device connections per year on airplanes served by the ViaSat-3-class satellites. Viasat's success in North America is helping the company engage with airlines on a global basis, commensurate with the expansion of Viasat's global satellite fleet. For example, Viasat recently partnered with China Satcom to provide in-flight connectivity to airlines over China.⁵



For these reasons, the capabilities and capacity afforded by the ViaSat-3-class design are truly transformative and will revolutionize the availability and coverage of broadband services delivered to homes and businesses in metropolitan urban and rural areas alike, and for both fixed and mobile applications.

Moreover, the ViaSat-3-class design includes a number of features that enable extremely secure and reliable service for the most demanding needs of government users. Viasat's current broadband services support a variety of military and national security initiatives, and provide reliable communications for first responders. Viasat has developed and enhanced security and encryption capabilities for military users and has been recognized for its forward-looking approach to cybersecurity services for government and military customers. The ViaSat-3-class design extends these types of features. Significantly, these features of the satellite network design will offer new resiliency and reliability capabilities for Government customers.

⁵ Viasat, China Satcom Partner to Bring In-Flight Connectivity Service to Airlines over China (23 April 2019), <http://investors.viasat.com/news-releases/news-release-details/viasat-china-satcom-partner-bring-flight-connectivity-service>.

APPENDIX B

Satellite in the 5G Ecosystem



ASIA-PACIFIC TELECOMMUNITY
The 4th Meeting of the APT Conference
Preparatory Group for WRC-19 (APG19-4)
7 – 12 January 2019, Busan, Republic of Korea

Document No:
APG19-4/INF-15

31 December 2018

VIASAT, INC.

INFORMATION DOCUMENT ON SATELLITE IN THE 5G ECOSYSTEM

Introduction

5G has been conceived as an ecosystem of many technologies – a network of networks – in which satellite plays a vital role in accelerating opportunity, maximizing network potential, and extending network reach.

The global Internet approach has been a powerful driver in providing world-changing economic opportunities. By integrating the unique benefits of every kind of network – copper, fiber, terrestrial wireless, and satellite – the Internet has become a global force that has created as much economic growth in 15 years as the industrial age created in 50 years.ⁱ This network of networks approach has been instrumental not only because it takes advantage of the unique capability of every available technology at the *core* of the network to extend its reach (fiber, copper, and satellite), but also through the variety of access technologies at the *edge* of the network – Wi-Fi, cable, DSL, LTE, and satellite to name a few.

This ecosystem approach has proven to be essential for leveraging the unique benefits of each type of network technology to expand the reach and capability of the Internet. The combination of cellular, Wi-Fi, satellite and other advances are enabling this same kind of ecosystem approach to be extended to the wireless world – both in the core of the network and at its edges – to expand the capabilities of mobile and fixed end user devices and the locations they operate.

At the dawn of the 5G world, advancing this 5G ecosystem architecture is even more vital. Too often, however, the only aspect of next generation wireless technology that is focused



on is the last 100 meter access link to the end user device. A myopic view of 5G – especially when it comes to spectrum – can limit its potential. Only through a holistic view of 5G, and a broad understanding of the comprehensive nature of the entire 5G ecosystem, can the full power and potential of next-generation wireless opportunity be realized. That’s because 5G is not a step change from 4G, nor is it just a technological shift. It’s a paradigm shift in the way we think about high speed mobile broadband networks. Today’s 5G vision encompasses a broad technology ecosystem – with multiple network technologies supporting a global infrastructure including traditional mobile wireless networks, satellite, Wi-Fi, and small cells.

The 5G network is envisioned as an access network-agnostic architecture that includes new cellular wireless access technologies (for the last 100 meter access), but also existing fixed wireless networks, Wi-Fi and satellite networks.ⁱⁱ These multiple access technologies are critical for optimizing the many different use cases envisioned for next generation networks. With advanced concepts of a unified user identity, users can be authenticated regardless of access technology enabling a seamless experience. The access technology and network technology are not inextricably linked but are decoupled to provide more flexibility for users and applications regardless, for example, if they are on a cellular network or Wi-Fi network. This multi-access capability can, for example, enable traffic to be offloaded from the mobile access network to other networks (for example to a satellite enabled Wi-Fi endpoint).

This 5G ecosystem approach is also essential for expanding the reach of 5G networks. By taking advantage of satellite’s geographically independent cost structure to extend connectivity, for example in underserved and unserved areas, satellite systems can accelerate the commercially viable deployment of 5G networks and extend scalable and efficient 5G network solutions globally. This is especially critical in areas that may not be economically or otherwise connected via terrestrial networks. Network diversity is also essential for ensuring network resiliency and continuity of service across geographies and enabling 5G devices to connect on truly mobile platforms including onboard aircraft, high-speed trains, sea-going vessels, and land-based vehicles that are beyond the reach of a cell site.

In order to fundamentally expand what networks are capable of achieving, and the places they are capable of reaching, a holistic approach is necessary to advance the entire 5G ecosystem of technologies. Harnessing the capabilities of satellite technology maximizes the reach and capabilities of 5G networks. Doing so also maximizes the ability of the 5G ecosystem to solve bigger problems – like extending high speed access to the next billion people, improving network resiliency, and enabling ubiquitous connectivity in the air, across the seas, and around the globe.

Nowhere is this more critical than in spectrum policy decisions. Having a holistic approach to spectrum policy that takes into account the unique capabilities of each technology is essential. This paper outlines the key spectrum decisions that enable the 5G opportunity to be maximized by embracing a holistic approach to the 5G ecosystem, and a holistic approach to the spectrum policy that accompanies this network of networks.

Next Gen Wireless Networks

It is important to be clear on the goals for the 5G ecosystem: To enable a connected world with ubiquitous access to the Internet by providing hyper mobility on land, sea and air for *all people everywhere*. This is more than just about the edge devices or the radio access; it is about providing a complete global network infrastructure.



Figure 1: The Connected World ⁱⁱⁱ

Clearly, this cannot be done with one wireless access technology or with one network. There will continue to be extensive use of multiple wireless technologies such as Wi-Fi, point-to-multipoint links, satellites and, of course, cellular. They all play an essential role in building an infrastructure that is adaptable to the ever-expanding new applications and environments.

Similarly, network infrastructure will continue to rely upon fiber, cable, microwave, satellite, HAPS (High Altitude Platforms) and mm-wave technologies to deliver on the ubiquitous and robustness promise. These hybrid networks must now enable greater capabilities to ensure security and accessibility and adaptive performance with simple hand-offs between peer networks.

With this more complete perspective of 5G we can now put in context a balanced roadmap to future wireless technologies which will include satellite, microwave, mm-wave, cellular and Wi-Fi networks that will collectively compete for the broadening demand for new applications. Each of these networks provides its unique value in user management, security and capabilities, yet each also connects to the global Internet in a consistent way to exchange data using compatible user authentication models.

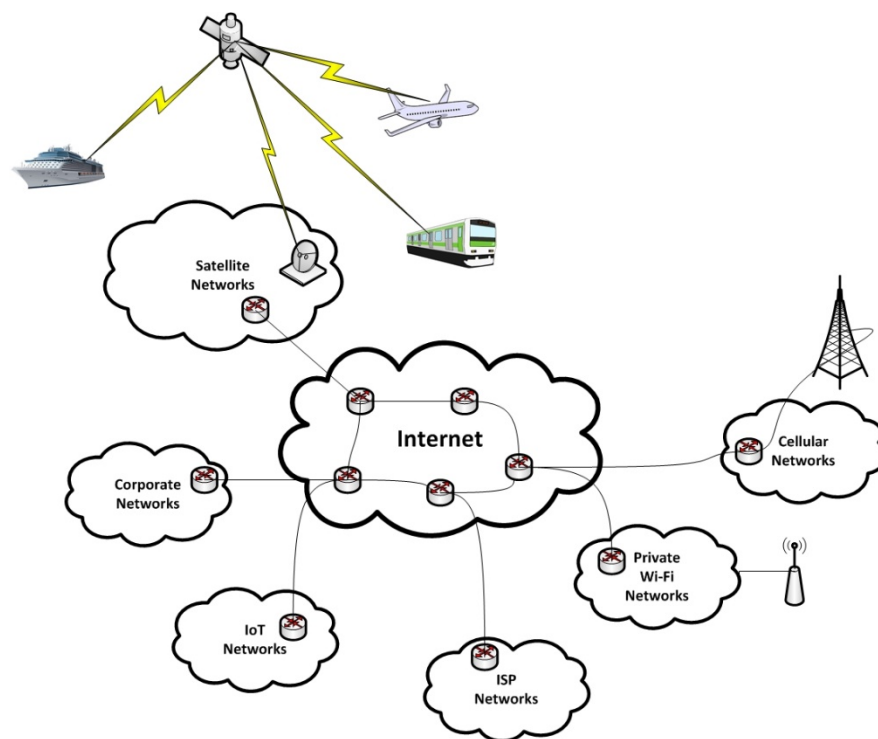


Figure 2: 5G Ecosystem – Network of Networks

This network infrastructure is invisible to most users but plays a critical role in delivering performance, security, value-added features, and authentication for the user. While most users rely heavily on their mobile devices, few realize that 63% of all mobile data actually is 'offloaded' to Wi-Fi and the Internet using unlicensed spectrum. As mobile data demand

increases so will this offload to unlicensed spectrum. By 2021, Cisco predicts that 5G cellular devices will represent only 0.2% of all connected devices in the world and will account for only 1.5% of network traffic. Cisco also predicts that by 2021 the total of all IP Internet traffic will exceed 84 exabytes of data, 50% will be Wi-Fi, 30% will be fixed and only 20% will be mobile data.^{iv}

It is this diversity of wireless access technologies as well as the inter-connectivity of network topologies that ensures a robust and resilient network ecosystem.

Current Satellite Capabilities

Both geostationary (GSO) and non-geostationary (NGSO) satellite networks have their specific benefits for the 5G ecosystem. Innovation is driven by development of High Throughput Satellite (HTS) systems in various types of orbits (GSO, MEO, LEO). HTS systems today deliver substantial improvements in throughput, capacity and cost, as well as provide flexible, global and high-performance services. This is done by utilizing concentrated spot beams, wideband payloads, increased frequency re-use and higher frequency bands to significantly increase capacity and speeds over wide areas. HTS networks are operating on a global basis and can provide broadband service with speeds in excess of 100 Mbit/s to the end user.

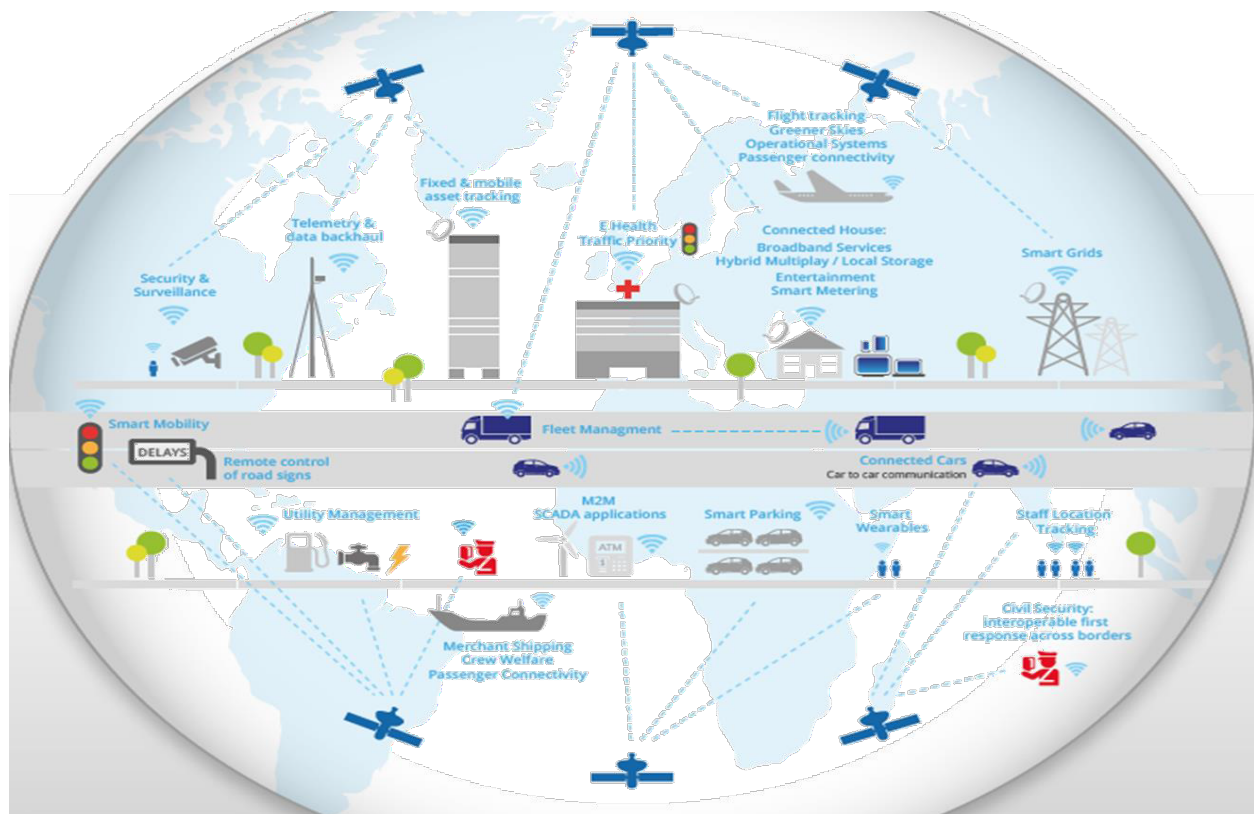


Figure 3: Satellites in the 5G Ecosystem^v

In addition to the developments in the space segment, there are technical developments in the satellite ground segment with evolutions both in the network platforms and satellite communication terminals and antennas. Satellite already has and will further adopt technologies and standards necessary to deliver the types of services needed in the 5G ecosystem, including in the areas of service delivery, network-slicing, orchestration, mobile edge computing, security, interoperability and resource virtualization in order to transparently support end-to-end service delivery to vertical applications. Furthermore, a new wave of flat panel antenna technology is emerging for satellite communications. These antennas have removed mechanical components, relying on software and electronics for steering, making them available for mobile platforms like cars, boats, planes and more.

Advanced Satellite Network Technology

Advanced satellite technology includes support for virtual network operators, traffic management, intelligent routing, quality of services, and other features. Some of these features are nearly unique to satellite communications, such as acceleration services to mitigate the impact of latency. Some, such as traffic enforcement, service accounting, and media services (including content rights management) are common among most access

networks. Some, such as mobility services, are similar to those employed in cellular systems but are tailored to the much larger reach of satellites.

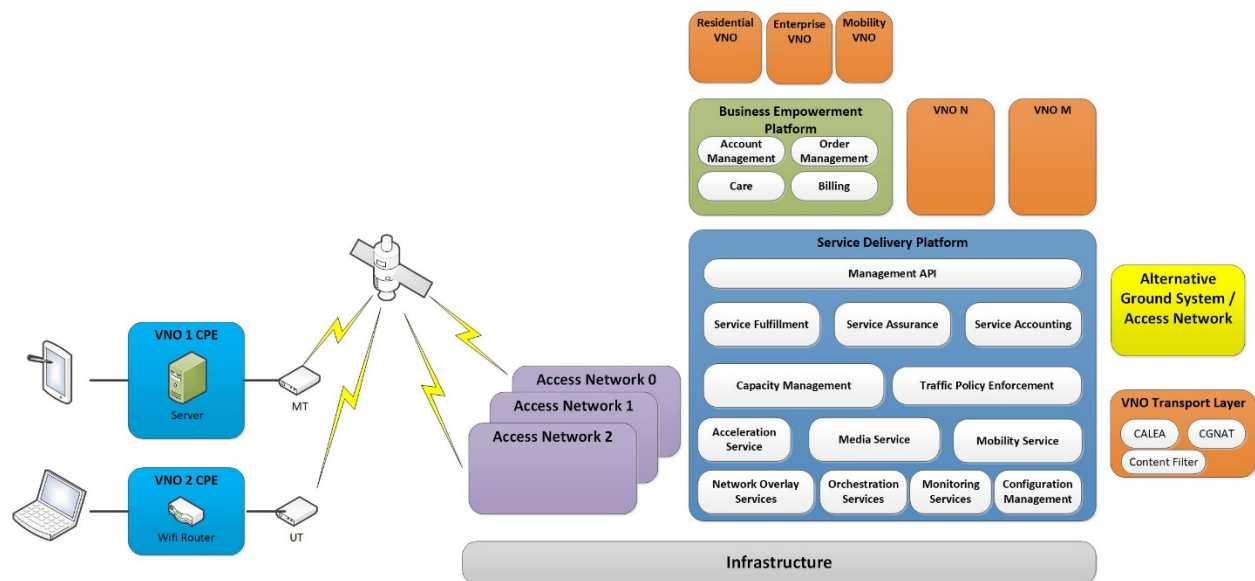


Figure 4: Satellite Ground System Components

Data can be routed between satellite beams within a satellite network, between satellite networks, and between satellite and terrestrial networks. This allows consistent, seamless connectivity for individual users whether they are in the air, on the water, in a vehicle or train, at home, in town, or in the office. The networks support multicast as well as unicast data efficiently.

Advanced satellite systems also include dynamic configuration management elements to enable flexible adaptation of device behavior suitable for operating across networks. This allows the networks to adapt over time and to change behavior as necessary to compensate for link dynamics.

Satellite Spectrum Technological Advancements

Commercial satellite networks have relied on access to the 27.5 – 30 GHz band (Ka Band) for over two decades to provide critical connectivity around the world. Today, over 130 GSO Ka band satellites are now in orbit, providing a wide range of services. Many more Ka band satellites (both GSO and NGSO) are under construction to meet the growing demand for service, and need to use the full 2.5 gigahertz of Ka band spectrum both to meet this demand, and because the Ka band orbital arc is becoming increasingly congested. While satellite use



of the Ka band has grown exponentially in the past few decades, the terrestrial mobile service simply did not develop in the Ka band, even though the ITU's Table of Frequency Allocations also provided an opportunity for that to occur.

For next generation satellites to provide high capacity connectivity, they need continued access to spectrum, and to employ the existing technologies that allow the spectrum to be used up to its technological limit. Modern satellite technology has developed to the point where it extensively employs frequency reuse technologies in which the same frequency band is used by one satellite to provide connectivity to many diverse locations at the same time by creating separate spatially isolated or orthogonal beams. Similarly, many different satellites use the same frequency band to provide connectivity to the same location. This is possible because each ground-to-satellite connection is from a different direction. The ground antenna can be a traditional parabolic dish, a horn array with mechanical steering, or an electrically-steered phased array.

In fact, satellite technology has advanced to the point that today's satellite broadband systems are approaching "Shannon's Limit" in terms of spectral efficiency.^{vi} Access to adequate spectrum is now the primary limiting factor in extending satellite broadband networks to address all of the unserved and underserved around the world, no matter whether they live in metropolitan areas or remote communities.^{vii}

Benefits for Consumers, Businesses, and Governments Provided by Satellite Today: Vertical Examples

As we enter a golden age of next gen satellite vast new opportunities come into view

Satellite is a vital part of the 5G ecosystem and is uniquely situated to solve key digital inclusion challenges, and expand global digital opportunity. As the world is blanketed with high speed broadband access, the opportunities become even greater, the technologies more transformative, and the impacts even more profound. Satellite systems already offer speeds today of up to 100 Mbit/s. Satellites currently under construction are capable of offering 1 Gbit/s, lightning-fast broadband speeds.

Connecting the unconnected: Today, more than ever, access to high speed broadband is an opportunity equalizer and economic accelerator. What once was a luxury is a necessity today. However, 3.9 billion people around the globe still do not have access to the Internet, and around one-third of the world's inhabitants still do not own a personal mobile phone.^{viii} High-quality and cost-effective satellite broadband is playing an increasingly important role in addressing this digital divide across the globe, for the unserved and underserved who exist everywhere, including in the most rural and remote areas of the world where it remains uneconomical for terrestrial or cellular services to build. The nature of satellite's wide

coverage ensures that all communities within a satellite network's footprint receive the same quality of service, whether they are in metropolitan areas or remote communities.

- In many cases, the digitally disconnected are the ones who can benefit most when they gain access to the global Internet and are digitally included. Connecting these people is essential for supporting freedom of information and speech, accelerating developing economies, improving access to education, empowering women and minorities, and advancing democratic societies. This is why the UN's 2030 Agenda for Sustainable Development has recognized that "global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies,"^{ix} and the UN's Human Rights Council has declared Internet access to be a basic human right.^x Satellite technology helps meet these objectives by blanketing the globe with this digital opportunity, extending access beyond the reach of terrestrial networks, and transforming the economics of global broadband reach. Indeed, among the UN's Sustainable Development Goals, the achievement of 38 targets depends upon universal and affordable access to broadband and the technologies needed to access broadband.^{xi} Satellite systems not only play an essential role in extending broadband connectivity globally, they also provide the connectivity for extending scalable and efficient network solutions globally. By taking advantage of satellite's geographically independent cost structure to extend connectivity, satellite today is helping provide connectivity to tens of millions of fixed and mobile end-user devices everywhere, including areas that are not adequately connected via terrestrial networks.
- It is also why the ITU's recently concluded Plenipotentiary Conference in Dubai, UAE, adopted modifications to Resolution 203 on Connectivity to broadband networks (Rev. Dubai, 2018) inviting Member States "to facilitate connectivity to satellite and terrestrial broadband networks, including enabling access to spectrum, as appropriate, as one important component of access to broadband services and applications, including to remote, underserved and unserved areas."

Enabling communications on the move. Satellite broadband is helping expand economic opportunity everywhere – on the ground, in the air, across the seas, and around the globe. Advances in technology make it possible today to deliver high-speed satellite broadband communications to consumers and businesses on the move – whether on an airplane (while waiting to take off, and at 35,000 feet), on a ship in the middle of the ocean, on a tractor in a remote and rural farm, on a bus or train in a city, or in an emergency vehicle speeding down the freeway on the way to a hospital. Already more than a thousand airplanes flying billions of air miles are accessing satellite-enabled high-speed Wi-Fi capable of streaming Internet and movies right to the seat. Wi-Fi on aircraft has become so popular that there are often



more connected devices than passengers on planes. Well over 60 million electronic devices already connect every year to satellite-enabled Wi-Fi on airplanes and this number is expected to increase exponentially to hundreds of millions in just the next 3-5 years as more aircraft become connected. Satellite's unique ability to provide connectivity across moving platforms is essential for enabling people with 5G devices to connect while on the move.

Extending Wi-Fi service. Satellite-based Wi-Fi services today connect users in metropolitan areas as well as unserved and underserved markets within the satellite network's coverage area. Satellite-based Wi-Fi is extending high-speed broadband access in unique ways to urban city centers, community recreation centers, airports, stores and shops. At the same time, large numbers of towns and villages worldwide have little to no Internet access. To address these broadband-challenged locations, satellite-powered hotspot service connects people in small villages and towns to the online world – affordably and reliably. Many people in these villages and towns have mobile smartphones, yet many do not have Internet service. By bringing a satellite-powered community 5G Wi-Fi service to these villages, made available through a shared satellite terminal, the residents gain access to high-speed connectivity. For example, today nearly one million people in thousands of locations that don't have 3G or 4G services can now connect their smartphones thanks to satellite-powered community Wi-Fi hotspots.

Unlocking new digital health opportunities. With too many people living in areas with only sporadic and even diminishing access to quality health care, satellite broadband technologies that span distance *today* are extending connected care *everywhere*. What was once a dream is now becoming a reality, that is, no one should be forced to put their life at risk simply because they live too far from a doctor. Satellite technology is cost-effectively overcoming a rural physician shortage, extending experts to where they are needed most, and delivering services regardless of where the doctor or patient is physically located. For example, satellites today are being used to connect ambulances in transit to doctors in hospitals to improve patient outcomes.

Improving disaster recovery and relief. Satellites networks provide high capacity and instantaneous connection to any place within their wide coverage areas. They are less vulnerable to physical attacks and natural disasters than terrestrial systems and satellite terminals can be rapidly deployed. Satellite networks can be especially important for improving 5G service resiliency, and for rapid deployments of high-speed wireless connectivity in emergencies and for disaster relief.

Advancing a new era of precision agriculture. Satellite broadband is helping enable a whole new generation of precision agriculture opportunities driven by broadband that enables remote farms –especially with livestock sensors, soil monitors, and autonomous farming equipment – far beyond where cell sites are likely to ever be deployed. Autonomous



farm equipment, already enabled by satellite positioning technology, often needs connectivity far beyond the line of site of a cell site.

Enabling competition. Just as it has with radio and television services in the past, Ka-band enabled satellite broadband services today are providing market-based competition to terrestrial broadband services. Satellite broadband brings additional service package options, greater capacity for video downloads and streaming, competitive pricing per gigabit, and innovative services to consumers who often have few choices from terrestrial providers. It is essential that satellite networks have secured access to sufficient spectrum to meet consumer demand, without having terrestrial competitors as a gatekeeper for spectrum access.

A holistic approach to 5G users access needs is essential

In order to maximize 5G high-speed broadband opportunities for everyone, it is critical that a holistic approach to the 5G future be considered. This means taking a comprehensive view of spectrum policy across the 5G ecosystem to ensure secure access to the spectrum needed by all technologies to enable universally-available advanced broadband services, including to densely populated cities and underserved and unserved areas, wherever located.

- 1. 5G solutions must ensure global digital inclusion.** As noted above, today some 3.9 billion people do not have access to the Internet, and around one-third of the world's inhabitants still do not own a personal mobile phone.^{xii} This lack of access has created a growing digital chasm between urban and rural, the wealthier and the less well off, and between developed and developing countries.^{xiii} It's one of the reasons that embracing a holistic network of networks approach to 5G is essential – enabling the whole panoply of network technologies to work together to extend the reach of broadband connectivity. As satellite systems with over one terabit per second of capacity now under construction are deployed and provide affordable broadband service to everyone, they will play an even more important role in extending digital connectivity to all communities and all citizens, wherever they are located, and wherever they may travel. **Thus, to extend and project the reach of 5G broadband access, both vital satellite technologies and reliable spectrum access for satellites are essential.**
- 2. A global spectrum strategy (that preserves critical Ka band spectrum for satellite) is essential for advancing digital opportunities.** Taking a holistic and harmonized approach to spectrum access is critical for ensuring that ubiquitous and

consistently high-quality connectivity is spread in the broadest possible ways. At the last ITU World Radiocommunication Conference in 2015 (WRC-15), global leaders took the critical step of providing certainty for existing satellite uses in the Ka-band by declining to study the possible introduction of 5G into the 27.5-29.5 GHz portion of the Ka band (28 GHz). The WRC-15's foundational decisions to preserve the 28 GHz band for satellite growth was based on the recognition that the 28 GHz band is essential for delivering high-speed satellite broadband to end users; and the demand for this spectrum is only increasing. European leaders have built upon this framework and harmonized the 28 GHz band for broadband satellite, which makes the band unavailable for 5G terrestrial access. In the wake of the WRC-15 decision, the satellite industry has invested billions in deploying many new networks that operate in the 28 GHz band (as well as the adjacent 29.5-30 GHz band segment), the benefits of which are described above. Technical studies from both 5G and satellite interests show that the 5G terrestrial access being proposed is incompatible with existing satellite operations in the 28 GHz band. Nevertheless, terrestrial wireless network manufacturers and carriers have suggested reopening the debate and repurposing the 28 GHz band for 5G terrestrial access. Continued certainty on use of the Ka band, including the 28 GHz band, is essential both for the continued operation of existing satellite broadband, and enabling the continued provision of satellite services as a part of the 5G network of networks, to extend the 5G opportunity. **Thus, satellite broadband must be allowed to flourish and innovate in the Ka band with the certainty that the spectrum will not be opened for incompatible services.**

- 3. This is not a choice between terrestrial 5G and satellite-enabled broadband.** There is more than enough spectrum for terrestrial 5G services in other bands being explored as a part of the WRC-19 agenda without denying satellite broadband the 28 GHz band spectrum that it currently uses. In fact, as a variety of 5G interests have indicated, the low and mid-band spectrum, beyond the 33+ gigahertz that the WRC-19 will consider, is much more attractive for 5G terrestrial access. 5G can be accommodated in 33 gigahertz of spectrum that the ITU is studying for use in 5G that doesn't include the 28 GHz band or the adjacent 29.5-30 GHz part of the Ka band.^{xiv}
- 4. Satellite access to the 28 GHz band is essential to prevent a balkanization of digital opportunity.** Sterilizing the 28 GHz band with unilateral national 5G spectrum strategies could severely impede opportunities everywhere – particularly in neighboring countries. The coverage areas and economies of scale necessary to bridge the digital divide require satellite broadband to have a broad footprint. One of

the major advantages of satellite communications is that their beams can cover large areas, across borders. The only logical solution is for countries to continue to embrace satellite broadband use of the 28 GHz band and not make it available for incompatible 5G cellular use. Failure to do so would mean that true 5G – and the broad benefits of its network of networks approach – could not be delivered to all the world’s population, and the vast satellite-enabled broadband opportunity would be balkanized and curtailed.

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- ⁱ McKinsey, The great Transformer: The impact of the Internet on economic growth and prosperity. https://www.mckinsey.com/~media/McKinsey/Industries/High%20Tech/Our%20Insights/The%20great%20transformer/MGI_Impact_of_Internet_on_economic_growth.ashx
 - ⁱⁱ Wireless Broadband Alliance, 5G networks. <https://www.wballiance.com/wireless-broadband-alliance-calls-for-industry-cooperation-to-harmonize-the-integration-approaches-of-wi-fi-with-5g/>
 - ⁱⁱⁱ ECC Report 280, Satellite Solutions for 5G, at 11, <https://www.ecodocdb.dk/download/e1f5f839-ba17/ECCRep280.pdf>.
 - ^{iv} CISCO: Global Mobile Data Traffic Forecast Update, 2016–2021 White Paper
 - ^v ECC Report 280, Satellite Solutions for 5G, at 13, <https://www.ecodocdb.dk/download/e1f5f839-ba17/ECCRep280.pdf>.
 - ^{vi} See <https://www.gaussianwaves.com/2008/04/channel-capacity/>. Today’s satellite systems provide actual transmissions at near the maximum capacity that theoretically can be achieved over a given amount of spectrum. This means that making more spectrum available is the only way to increase satellite capacity and serve more end users.
 - ^{vii} These points were recently highlighted by Dr. Pace, the Executive Secretary of the White House National Space Council: “The United States has a strong and entrepreneurial satellite communications industry, available to engage in global competition.... The United States has a strong and entrepreneurial satellite communications industry, available to engage in global competition... There’s an urgent need to provide reasonable protections

for satellite gateway earth stations in certain frequency bands, as well as protection for satellite end user terminals in core satellite bands ... It's for those these reasons that the National Space Council is examining how the Department of State, Commerce and the FCC can better coordinate to ensure the protection and stewardship of spectrum necessary for space commerce. <https://spacenews.com/space-council-seeking-to-protect-satellite-spectrum/>.

viii https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.18-2017-PDF-E.pdf

ix <https://sustainabledevelopment.un.org/post2015/transformingourworld>

x https://www.article19.org/data/files/Internet_Statement_Adopted.pdf

xi Among the UN's Sustainable Development Goals (SDGs) there are no fewer than 38 targets whose achievement will depend upon universal and affordable access to ICT and Broadband. <https://www.broadbandcommission.org/about/Pages/default.aspx>

xii https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.18-2017-PDF-E.pdf

xiii <https://news.itu.int/broadband-sustainable-development/>

xiv The current WRC Agenda for the 2019 Conference has identified several bands under WRC 2018 Agenda Item 1.13 for possible identification for terrestrial IMT-2020 (also known as 5G). These bands include: 24.25-27.5 GHz, 37-40.5 GHz, 42.5-43.5 GHz, 45.5-47 GHz, 47.2-50.2 GHz, 50.4-52.6 GHz, 66-76 GHz and 81-86 GHz (Proposed IMT Bands). Other bands (31.8-33.4 GHz, 40.5-42.5 GHz and 47-47.2 GHz) are being considered for co-primary allocation to the mobile service and identification as well to the terrestrial component of IMT.