Your response

Your response should include details of:

- a description of the relevant technology;
- a view of the potential impact of the technology on the sectors we regulate, preferably identifying the impact against the criteria listed in section 3.16 of the call for inputs;
- the current state of development of the technology, including any demonstrations of feasibility;
- any unresolved issues which need to be addressed for the technology to achieve full potential;
- references to key publications and the leading groups working on the technology; and
- whether you would be open to discussing the technology in more detail with Ofcom.

Your response
Confidential? No

Emerging technologies and their potential impact on the communications industry

Response to UK Ofcom Consultation
Submitted to emerging.technology@ofcom.org.uk

September 2020

Executive Summary

As Ofcom considers emerging technologies and their impact on the communications industry, this paper outlines existing and future advancements of satellite-powered broadband technology, the impact these advancements play in making an affordable, reliable and effective solution available to UK consumers, and regulatory policies that promote growth and have a positive impact on UK consumers. Satellite-powered broadband is quick, trench-free deployment without the adverse environmental impacts of terrestrial based solutions. Satellite-powered broadband increases customer choice by delivering a broadband service option of up to 100 Mbit/s to consumers in the air, at home in cities or rural areas alike.

Viasat is a global leading provider of communications solutions across a wide variety of technologies (both terrestrial and satellite) with a strong presence in the UK. Viasat UK is building on its heritage of secure encryption to provide communications solutions for the UK Ministry of Defense (MoD) including Government Communications Headquarters (GCHQ) to satellite communications for government, civil and commercial users more generally.

As the world's only vertically integrated end-to-end satellite operator, we design and build every component of our system—user terminals, satellite payloads and ground stations—to meet the demand for reliable, effective and affordable broadband connectivity everywhere. This vertically integrated approach includes network security that enhances the user experience for our consumer and government customers. The network also incorporates network management techniques including machine learning and artificial intelligence to improve network management and efficiency. These network management techniques improve the user experience, increase accessibility and affordability for customers.

Today, Viasat makes high-speed broadband services available to millions of households and businesses in North America, Latin America,[1] Australia,[2] and across Europe[3]. Viasat also connects airline passengers around the world with a home-like broadband experience wherever they travel.

Satellite technology's impact on the communications industry depends on two factors: delivered value to customers (what customers want) and strong geographic market selection

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[1] https://viasat.com.mx/community-wi-fi/?lang=en; *Viasat Brings Fastest Home Satellite Internet Service to Mexico,* https://www.viasat.com/news/viasat-brings-fastest-home-satellite-internet-service-mexico; *Viasat, Visiontec Broaden Brazilian Partnership to Focus on Delivering High-Speed, High-Quality Satellite Internet to Homes across Brazil,* https://www.viasat.com/news/viasat-visiontec-broaden-brazilian-partnership-focus-delivering-high-speed-high-quality.

[2] *ViaSat Wins $286M Satellite Broadband Deal with Australia,* https://spacenews.com/viasat-wins-286m-satellite-broadband-deal-australia/.

[3] Viasat's expansion in Europe helps bridge the gap to faster broadband (video) https://corpblog.viasat.com/viasats-expansion-in-europe-helps-bridge-the-gap-to-faster-broadband/; *Viasat Affirms Commitments to Bring its Powerful ViaSat-3 Satellite to Europe,* https://www.viasat.com/news/viasat-affirms-commitments-bring-its-powerful-viasat-3-satellite-europe; Viasat Affirms Commitments to Bring its Powerful ViaSat-3 Satellite to Europe, https://www.viasat.com/news/viasat-affirms-commitments-bring-its-powerful-viasat-3-satellite-europe.

(where customers are). Success is determined by delivering what customers value — which is speed at an affordable price.

Current UK market conditions indicate that satellite broadband technology advancements can be an important solution to serving unmet connectivity needs. The UK has a high number of geographically dispersed households and small businesses in both metropolitan and rural areas (*i.e.,* where customers are) currently served with low speeds (*i.e.,* not providing what customers want). These UK households and small businesses are served with legacy DSL or are not served at all. Additional broadband needs in the UK include mobile and government customers.

The ViaSat-3 constellation, currently under construction, is designed to deliver high-speed, affordable broadband connectivity. The second of the three ViaSat-3 satellites covers the UK. Additional satellites will be deployed to meet additional demand, as needed. Also, Viasat is preparing to bring to the UK several network enhancements that improve the user experience to the UK including its recently-developed SD-WAN solution, which combines fast-broadband satellite capacity with terrestrial service capabilities.

A primary driver to realize satellite's technology advancement is lowering barriers to market entry including regulatory policies that invite emerging technologies to compete for UK consumers. Predictable access to spectrum is critical to allow for long term investments in innovative technologies. Viasat's current satellite system is based principally on the use of the Ka band. Ka band spectrum is the key that allows satellite broadband to expand to meet demand and unlocks the barrier to future satellite-powered broadband growth in the UK.

I. Description of the relevant technology

As we have observed during the pandemic, demand for connectivity has firmly established the enormous and growing demand for universal broadband – for home, work, education, health, entertainment, communication, information and security.

To meet the demand for connectivity highlighted by the pandemic, today's Very High Throughput Satellites (VHTS) systems 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. VHTS networks are operating on a global basis and can provide broadband service with speeds in excess of 100 Mbit/s to the end user.

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. It should be noted that 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, security, interoperability and resource virtualization in order to transparently support end-to-end service delivery to

vertical applications. Satellite's role in the 5G ecosystem will be discussed later in this paper. On the antenna front, VHTS systems deliver mobile satellite broadband communications using antennas called Earth Stations in Motion (ESIMs). These ESIMs provide connectivity to aircraft gate-to-gate, land mobile platforms like trains and buses and maritime vessels traveling pier-to-pier. To further satellite broadband adoption and ease of use, a new wave of flat panel user antenna technology is emerging for satellite communications. These antennas have removed mechanical components, reduced size, relying on software and electronics for steering, making them available for mobile platforms like cars, boats, planes and more. Later in this paper, Viasat highlights how ESIMs enhance the user experience for airline passengers and flight operations for airline crew today. Further, the 5G use cases section of this paper outlines how satellite mobile broadband enabled by ESIMs is a clear, proven demonstration of the feasibility of satellite broadband technology.

VHTS systems use the 27.5-31 and 17.7-21.2 GHz portions of the Ka band to deliver satellite broadband connectivity around the world. Satellites using these bands bridge the digital divide and provide ubiquitous connectivity that no other technology can offer during normal and times of disaster and other crises.

II. Impact of the technology. How does it enable the delivery of new services which are valued highly by people and businesses?

a. Broaden and deepen access to services.

Provision of competitive services. Ka band satellite systems provide services that are competitive with, and in some cases superior to, terrestrial service. Ka band spectrum "powers" satellite broadband services that:

- Can be offered at speeds of 100 Mbit/s and higher.
- Can be deployed to a given location almost immediately through a small antenna that can be mobile, transportable, or fixed in place, depending on end-user requirements, and that does not need to be individually licensed or coordinated.
- Are extendable to anyone near that satellite antenna by using a Wi-Fi hot spot to distribute the satellite connection—whether to entire communities or everyone on an airplane, ship, train or bus.
- Meet needs that no other technology now addresses, or will address, including:
    - Connecting otherwise unserved and underserved families, communities, and small businesses around the world, many of whom are located in pockets of heavily populated areas;
    - Connecting widely-dispersed government facilities;
    - Connecting passengers and crew on trains, buses, ferries, ships and aircraft;
    - Supporting emergency responders, national defence and security;
    - Enabling disaster recovery and relief operations; and
    - Providing always-available global communications capabilities.

- Meets further important policy goals, such as enabling telemedicine and connecting healthcare facilities, facilitating precision farming, monitoring critical infrastructure, extending access to education and libraries, supporting the development of e-commerce, access to banking, and the creation of new jobs.

b. Increase the performance of networks, improving the experience for people.

Viasat's investment in satellite broadband technology is transforming the customer experience. There are two examples of the changes that customers experience— (1) increased capacity of our satellite networks with a keen focus on significantly increasing speed and volume; and (2) network management and operations practices and applications that improve the customer experience. While improving the customer experience through efficiencies, these network improvements also lower network operating costs. The result, which Viasat passes along to its customers, is increased broadband accessibility and affordability.

Viasat network capacity increases improve the user experience. Viasat's satellite system is optimized for video streaming, the dominant use on the Internet, through increased speed and volume. The ViaSat-1 satellite with 140 Gbit/s of total network capacity delivered speeds of 12 Mbit/s with volume service plans similar to the cellular data plans. The service plans also successfully compete with DSL. The ViaSat-2 satellite increased total network capacity to 260 Gbit/s with 7x the coverage area of ViaSat-1. On the ground, customers across a wider geographic area enjoy service plans of up to 100 Mbit/s with, in some cases, no volume caps. In the air, ViaSat-2 allows customers to enjoy the same video streaming experience for gate-to-gate service on their own personal electronic devices onboard commercial aircraft. The next generation satellite system, ViaSat-3 has total capacity of 1,000 Gbit/s. In the next couple of years, a series of three ViaSat-3 satellites will cover the globe delivering ubiquitous, reliable, high-speed broadband. These capacity increases and expanded geographic reach deliver high-quality broadband for customers where ever they may go.

Advanced network automation improves network operations and the user experience. Viasat's network employs advanced network automation to improve customer satisfaction, increase service provisioning, and reduce the cost of network operations by minimizing manual operations. Smart network automation techniques include:

- Software-defined networks (SDNs) that enables the network to be centrally controlled, or 'programmed,' using software applications;
- Intent based networking (IBN) that employs artificial intelligence and machine learning to perform routine tasks for every network phase including provisioning, deployment, management, troubleshooting, and remediation; and
- Data driven networking (DDN) that allows the network to 'learn' using data analytics to optimize network traffic management.

Viasat SD-WAN enhances the user experience via terrestrial networks. Another innovative service that Viasat is planning for the UK is Viasat's revolutionary software defined radio wide area network (SD-WAN) service, called "Flex". With this service, Viasat satellite broadband is combined with terrestrial technology such as DSL or terrestrial wireless. Viasat's SD-WAN technology intelligently routes services over the optimal network to maximize the user experience. Viasat's SD-WAN seamlessly provides users with high speeds, low-latency, and high-availability enabling users with existing slow or unreliable terrestrial services (like so many with DSL in the UK) to stream to multiple devices at once, enjoy online gaming, download large files fast, and work-from-home.

SD-WAN applies established software-defined concepts to the wide area network, including access, and it separates control of the network including switching, routing and transport. This allows a network to be assembled from disparate component wide-area networks, leading to marked improvements in performance, resilience, affordability, and rate of innovation. SD-WAN supports modern applications such as VoIP calling, videoconferencing, streaming media, and virtualized applications and desktops, as well as the increasing bandwidth for applications such as high-definition video.

Viasat's web accelerator browser. To improve the customer experience, Viasat developed a web browser that is faster, improves privacy and saves data. Using artificial intelligence, the Viasat browser predicts what will be needed to render webpages, pre-fetches that content and delivers it to the user to significantly accelerate webpage loading.

The Viasat browser also saves data for users. The amount of data contained in a single webpage has grown substantially largely due to the increased use of images and video. Images that haven't been scaled for the web, poorly written code, embedded media and flash software add still more drag and detract from the user experience. To save data, the Viasat browser includes a built-in data saver mode that blocks audio and video HTML5 streams from pre-loading so that users avoid consuming data for unwanted content. All of these advances are designed to improve the browsing experience on all types of networks, including satellite networks.

Viasat network improves airline passenger user experience and flight operations. Viasat's network capacity affords airline passengers a superior inflight experience and also provides airlines and crew the ability to connect to flight operations in real-time. Viasat's high capacity network provisions sufficient capacity to connect all passengers to the internet at the same time. Passengers experience an at home internet experience inflight. Passengers can livestream watch TV, listen to music, shop online and browse. Also, using the artificial Intelligence techniques mentioned earlier, Viasat's technology pre-fetches large portions of content like frequently watched movies or songs and stores them locally on board the aircraft, eliminating the round trips over the satellite that would otherwise slow down the user experience.

For flight operations, the Viasat high capacity network converts manual, paper-based functions performed when the airplane is on the ground to real-time gate-to-gate capabilities, whether at the gate, taxing, or in-flight. Real-time gate-to-gate communications stream vital cockpit data, convert paper-based pilot flight bag materials to an electronic flight bag (EFB) capable of live updates, and enabling in-flight crews connectivity to the airline maintenance and operations on the ground. These operational efficiencies are part of an ongoing digitization of airline fleets[4].

c. Lower barriers to entry into markets, giving people a greater choice of providers.

Lowering barriers to entry to satellite broadband providers can help address the needs of UK residential broadband consumers. More competition results in more choice for consumers. The lack of UK consumer choice of high-quality broadband is evidenced by several factors including: a high number of unserved and underserved locations, geographic dispersion around the nation, the prevalence of DSL deployment, and the current low advertised speeds of existing providers. For a detailed discussion of the factors resulting from the lack of UK consumer choice, we refer you to Viasat's previous submission to UK Ofcom entitled *Satellite Broadband and Space Spectrum Policy*, June 2020. That document highlights the unmet demand in the UK broadband market that satellite is uniquely suited to address. The key to unlocking this unmet demand is access to spectrum for satellite services in the UK, particularly the Ka band.

Spectrum is essential for satellite services in the same way that it is for other wireless services. Just like terrestrial networks, satellite networks also scale over time to meet growing customer demand through investments that are no different than those needed to scale terrestrial networks.

Maximizing spectrum efficiency. Advanced satellite broadband services and capabilities described in this paper are made possible by increased spectrum access in the Ka band. Satellite technology has advanced to the point that today's satellite broadband systems are approaching "Shannon's Limit" in terms of spectral efficiency.[5] Access to adequate spectrum is now the primary limiting factor in extending satellite broadband networks to address UK consumers and consumers around the world.

The needs of the satellite industry have long been recognized by the International Telecommunication Union (ITU). Consistent with the primary ITU allocation of the entire

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[4] *Sky High Economics – Chapter Two: Evaluating the Economic Benefits of Connected Airline Operations* London School of Economics, (June 2018), https://www.lse.ac.uk/business-and-consultancy/consulting/consulting-reports/sky-high-economics-chapter-two.

[5] *See* M. Viswanathan, Channel Capacity & Shannon's theorem - demystified, GAUSSIANWAVES, Apr. 23, 2008, 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.

27.5-31 GHz and 17.7-21.2 GHz bands to FSS globally, Viasat and other members of the satellite industry have made significant investments in satellite infrastructure that has already been deployed, and even more that is being constructed for deployment in the next few years.

Viasat and other satellite operators have designed, invested and begun to deploy global broadband networks based on the decisions from WRC-15 including the global FSS allocations and the decision to put 5G/IMT in bands other than the 27.5-29.5 GHz (28 GHz) and 17.7-19.7 GHz (18 GHz) bands. That global consensus continues to be affirmed. Over 120 countries (a rising number) have expressed their intention to follow the WRC decisions and preserve the 28/18 GHz bands for satellite broadband services and accommodate 5G/IMT technology in other globally harmonized bands, including over 17 gigahertz of separate mmWave spectrum made available by WRC-19 for 5G/IMT, particularly the 26 GHz band.[6] Some 4.3 billion people represented by Europe, Indonesia, Australia, India, China, Russia, Bangladesh, Nigeria, Brazil, and Mexico, to name a few, support preserving the 28/18 GHz bands for satellite and more importantly, not adopting those bands for 5G/IMT use.

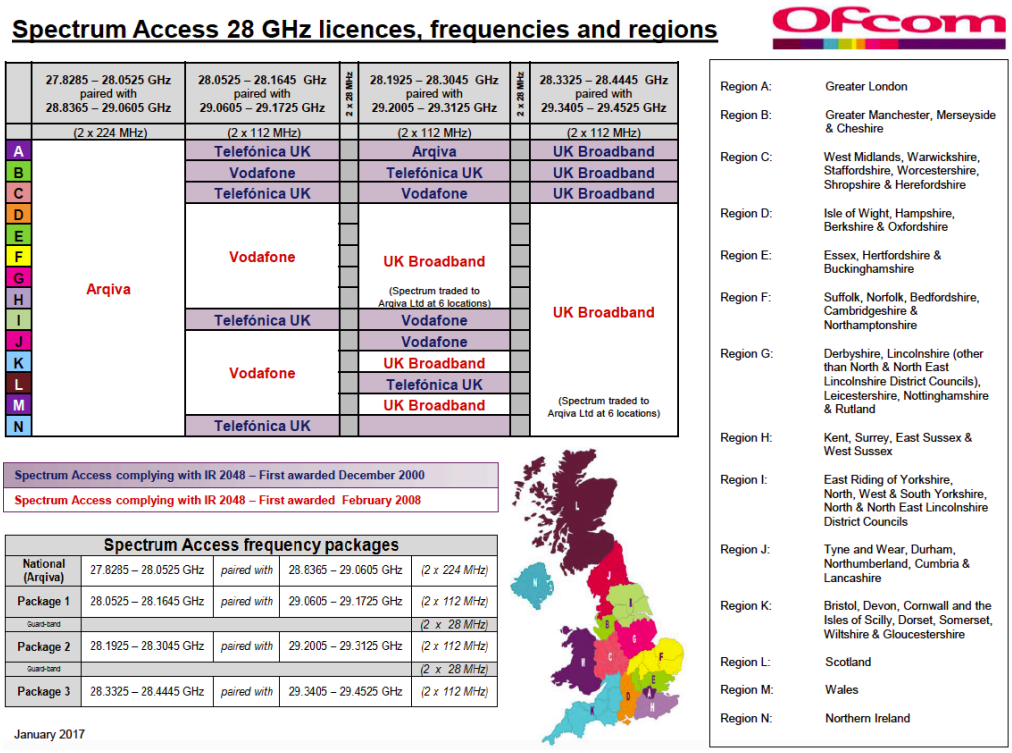
Viasat recognizes that Ofcom adopted a different band plan for the 27.5-29.5 GHz portion of the Ka band (28 GHz) in November 2000. Notably, that decision was made prior to the advent of today's satellite broadband systems. And it was not adopted with a vision to allowing the 28 GHz band to be used for the types of 5G/IMT systems being advocated today, which are designed in a manner that is fundamentally incompatible with other uses of the same spectrum.

Viasat takes this opportunity to comment on how the current UK band plan for the 28 GHz band has impacted the deployment of satellite broadband in the UK.

The chart below (Figure 1) outlines the 28 GHz band plan in the UK. The 28 GHz band was auctioned to Arquiva, Telefonica UK, Vodafone and UK Broadband, and adjacent guard bands were created, resulting in three segments of 28 GHz band spectrum for satellite services totaling approximately 728 megahertz in the following band segments 27.5-27.8185, 28.4545-28.8265, and 29.4625-29.5.

[6] 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/.

Figure 1: UK Spectrum Access 28 GHz Licenses



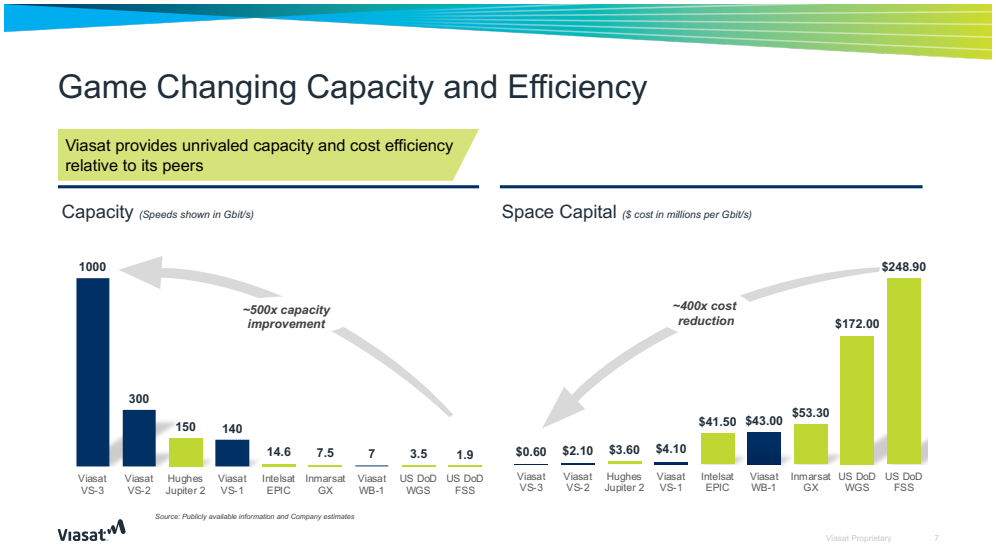
The band segmentation constrains the amount of satellite capacity that can be made available for service to UK consumers. As an initial matter, there is a direct correlation between spectrum availability and capacity of a satellite. The consequence of limiting spectrum availability is directly related to the next section which is a discussion about reducing the cost-per-bit of providing service. For additional comments on how spectrum constrains satellite broadband's ability to meet UK demand we again refer you to Viasat's submission to Ofcom entitled *Satellite Broadband and Space Spectrum Policy*, June 2020.

d. Reduce the cost of delivering services, increasing access and maximizing value for customers.

Viasat is innovating to drive down bandwidth costs. As the previous section outlined, efficient spectrum use is the key to driving down bandwidth costs (measured as cost per bit), increasing broadband access and delivering value for customers. Figure 2 below demonstrates the cost per bit reduction that Viasat is providing to consumers with the introduction of ViaSat-3 satellite technology. The left side of the chart shows the 500x

capacity improvement from 1.9 Gbit/s of capacity on a commercial satellite leased by the US government to ViaSat-3 that will cover EMEA (including the UK) with 1,000 Gbit/s of total capacity. With similar satellite system costs and the capacity improvements, the right side of the chart shows the 400x reduction in the cost per bit. This dramatic improvement drives down the cost of delivering services and increases capacity to serve broader markets.

Figure 2: Bandwidth Economics, Reducing Cost per Bit



e. Change the way we authorize and regulate networks and services.

See section II, C page 9 in this paper titled, *Lower barriers to entry in markets…* which discusses the need for adequate access to spectrum.

f. Assure the security and resilience of service delivery.

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 provides reliable communications for first responders. Viasat has developed and enhanced security and encryption capabilities for critical users and has been recognized for its forward-looking approach to cybersecurity services for government and military customers. The ViaSat-3-class design will extend these types of advanced security and encryption features to the United Kingdom market.

In addition to a secure network, Viasat's security capabilities extend to the device level. An example of this is Viasat's Mobile Dynamic Defense (MDD) cybersecurity software which is now available to protect the new Samsung Galaxy S20 Tactical Edition (TE) smart

phone.[7] The Viasat MDD platform will ensure sensitive Five Eyes (FVEY) allied forces including the UK, hosted on the Samsung Galaxy S20 TE device, are continually monitored and protected from compromise—even if the device is disconnected from the military or government operations center. Viasat's integrated mobile cyber-defense solution enables missions to be completed without the fear of jeopardizing confidential military or government policy, proprietary information or device integrity.

g. Reduce the total environmental impact of delivery of communication services and associated activities.

In 2019, Viasat was named to Fortune Magazine's Change the World list, a global ranking of top companies making a positive social impact through activities that are integral to their core business strategies and operations.[8] Viasat was selected for its ability to bring digital and social inclusion to the world through its innovative and low environmental impact satellite connectivity systems. Viasat was first to launch a highly-scalable satellite-enabled Community Internet initiative, that brings high-speed, affordable Wi-Fi directly to consumer's devices in rural and remote towns and communities. The Viasat service requires minimal local infrastructure, is economically self-sustaining and rapidly deployable in remote places where terrestrial fixed and wireless services struggle to perform, or may never reach.

Since the initiative's launch, Viasat has brought Community Internet connectivity to people in Mexico and Brazil, with near term plans to expand into other countries globally. Specifically, in Mexico, Viasat's Community Internet service is now within reach of more than 1.7 million people in unserved and underserved communities—delivering speeds of up to 100 Mbit/s—at prices as low as 50 cents per hour.

III. Current state of development of the technology, including any demonstrations of feasibility.

a. Current state of development of the technology.

Ten years ago, Viasat described the potential for ViaSat-1, the first Ka-band high-capacity satellite, to transform satellite broadband. And, that's what happened. Ten years later, our consolidated revenue has more than tripled. Viasat's Satellite Services segment which includes connecting consumers to the internet grew over 10 times. In 2018, ViaSat-2 our second-generation satellite further improved bandwidth productivity, expanded geographic coverage and introduced technology to better aim

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[7] Press Release, *Viasat Mobile Dynamic Defense Software Integrated into the Samsung Galaxy S20 Tactical Edition Solution Ecosystem*, (Aug. 17, 2020), https://www.viasat.com/news/viasat-mobile-dynamic-defense-software-integrated-samsung-galaxy-s20-tactical-edition-solution.

[8] Press Release, *Viasat Named to Fortune Magazine's 2019 Change the World List*, (August 19, 2019), https://www.viasat.com/news/viasat-named-fortune-magazine%E2%80%99s-2019-change-world-list.

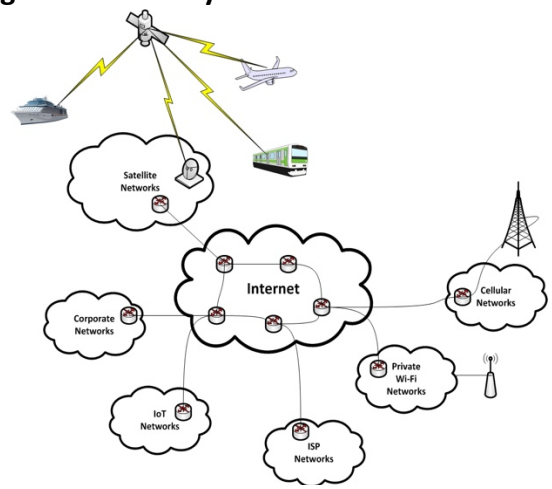
more bandwidth at places with higher demand. In 2015, we began construction on our first ViaSat-3 class satellites, and the first ViaSat-3 payload is nearing completion and the second of the ViaSat-3 constellation that will provide service to the UK has achieved important payload and ground network assembly test and integration milestones. Each ViaSat-3 satellite in our three-satellite constellation is expected to be capable of delivering greater than one Terabit per second (Tbit/s) of total network capacity. The ViaSat-3 constellation will also provide "visible earth" coverage and be able to dynamically steer bandwidth to places with higher demand. ViaSat-1 and ViaSat-2 have transformed expectations for satellite broadband. Our residential plans in the U.S. deliver more speed and bandwidth than any other home satellite service – up to 100 Mbit/s in some areas. Viasat pioneered the availability of free, high-quality in-flight satellite Wi-Fi to every passenger on a plane – including video and audio streaming.

Building on the successful service offerings of ViaSat-1 and Viasat-2, the even more capable ViaSat-3 will enable hundreds of thousands of people to simultaneously stream more hours of video, browse more web pages, experience more social media, enjoy more music, and communicate more with remote friends and family. The service will also include the latest Wi-Fi capabilities and can be bundled with VoIP services.

Viasat is already developing the next generation of high-throughput satellites that builds on current success to meet growing demand throughout the world, in Europe, and in the United Kingdom. While the ViaSat-3 constellation is designed to establish global coverage, Viasat's fourth generation satellites will be regionally focused to align capacity with specific market demand within that global coverage area. Like terrestrial telecommunications, Viasat's satellite network will be built out to meet demand in markets including the UK.

b. Satellite in the 5G Ecosystem

Figure 3: 5G Ecosystem Network of Networks



With an outline of the dramatic improvements in satellite technology described in the previous section, this section discusses satellite's powerful role in the 5G Ecosystem depicted in Figure 3 above.

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.

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.[9] 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.

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.[10] 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 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

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[9] 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.

[10] *Wireless Broadband Alliance, 5G net*works. https://www.wballiance.com/wireless-broadband-alliance-calls-for-industry-cooperation-to-harmonize-the-integration-approaches-of-wi-fi-with-5g/.

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 aircraft traveling gate-to-gate, sea-going vessels pier-to-pier, and land-based vehicles, such as high-speed trains or buses wherever they go. Demonstrations of this technology advancement is in the next section.

c. Demonstrations of the feasibility of the technology: Use Cases.

Satellite's ability to connect 5G devices to mobile and fixed platforms demonstrates the feasibility of the technology.

Maritime airlines, trains, 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 gate-to-gate, on a ship pier-to-pier, 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 traveling billions of miles are accessing satellite-enabled high-speed Wi-Fi capable of streaming Internet and movies right to the seat. Today, for example, Viasat provides over 150 million connections annually to personal electronic devices on almost 1,500 commercial aircraft. In many cases, there are more personal electronic devices connected than passengers on a plane.

To enable communications on the move, Viasat has pioneered mobile broadband services using innovative antenna designs called Earth Stations in Motion (ESIM) to aircraft, ships and other land-based users mentioned earlier. Viasat mobile broadband terminals deliver two-way IP communications. Today, Viasat's ESIMs bring faster in-flight internet speeds over more of the globe by accessing the best available satellite service on Viasat's global mobility network. This advanced aviation system allows for roaming between Viasat high capacity Ka-band and Ku-band networks and is capable of connection speeds of 70 to 100 Mbit/s to the aircraft. 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, including Viasat's Community Internet service mentioned earlier, 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 Internet service to these villages, made available through a shared satellite terminal, the residents gain access to high-speed connectivity.

Telehealth, 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 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 and enables telemedicine by connecting doctors with patients in their home or at central clinics.

Viasat has partnered with a company called 19Labs to deliver remote healthcare including enrollment, taking vital signs, doctor visits and patient instructions and education. This "Doc in a Box" solution, recently deployed in certain markets, brings the clinic to patients and connects patients to doctors over the internet using a portable satellite terminal for temporary locations and a residential grade satellite terminal for fixed locations.

Figure 5: Telemedicine in a Box

Education, remote learning. As schools around the world respond to COVID-19, the need for remote learning has never been more urgent. The rapid and massive shift to remote learning revealed that access to broadband remains inadequate for millions around the world; and many schools lack the technological infrastructure or resources to ensure all students can learn online. To enable the transition to distance learning, satellite broadband borrows similar protocols from the telemedicine example discussed above. The 19 Labs platform transforms from telehealth to education instead of bringing the doctors to patients, satellite broadband connects educators to students.

Improving disaster recovery and relief. Satellite 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.

IV. Unresolved issues which need to be addressed for the technology to achieve full potential

See section II, C page 9 of this paper titled *Lower barriers to entry in markets*… which discusses the need for adequate access to spectrum.

V. Other

a. References to key publications and the leading groups working on the technology

Industry Organizations include: European Space Agency (ESA), EMEA Satellite Operators Association (ESOA), Satellite Industry Association (SIA)

b. Whether you would be open to discussing the technology in more detail with Ofcom

Viasat would be happy to discuss satellite broadband technology in more detail with Ofcom.