December 13, 2021

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Viasat Inc.'s Response to Consultation Paper on Recommendation to Amend the Telecommunications (Fees) Regulation of the ECTEL Member States for New Satellite Services (November 30, 2021)

Viasat, Inc. ("Viasat") would like to thank the Eastern Caribbean Telecommunications Authority ("ECTEL") for the opportunity to comment on the "Consultation Paper on Recommendation to Amend the Telecommunications (Fees) Regulation of the ECTEL Member States for New Satellite Services" ("Consultation").[1] Viasat acknowledges that one of ECTEL's main priorities is to improve access to reliable broadband services in the five ECTEL Member States, namely the Commonwealth of Dominica, Grenada, Saint Lucia, the Federation of St. Kitts and Nevis and St. Vincent and the Grenadines.

As outlined in its Consultation, ECTEL seeks to "make recommendations on the best regime to be adopted by ECTEL in the pricing of radio frequency applications for satellite communications and an appropriate fee structure for Very Small Aperture Terminal ("VSAT") and Satellite Earth Station ("SES") services in the ECTEL Member States."[2]

Viasat is pleased to provide comments relating to ECTEL's proposed fee structure for new satellite services. Viasat also welcomes the opportunity to advise ECTEL of important developments within the satellite industry that ECTEL, the National Telecommunications Regulatory Commissions and the Council of Ministers should consider as they embrace the potential entry of a new era of satellite communications services. As ECTEL recognizes with the publication of this Consultation, there has been an unprecedented introduction of non-geostationary (NGSO) satellite systems. Many of these mega-constellation satellite systems consist of designs that were never anticipated, some with tens of thousands of satellites planned in low earth orbit (LEO).

Viasat agrees that many of these NGSO systems may present a number of new opportunities. However, Viasat cautions that many of these NGSO systems present significant and unanticipated issues, including constraining access to the limited and shared spectrum and orbit resources long used by geostationary

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1 Consultation Paper on Recommendation to Amend the Telecommunications (Fees) Regulation of the ECTEL Member States for New Satellite Services, https://www.ectel.int/consultation-on-recommendation-to-amend-the-telecommunications-fees-regulations-of-the-ectel-member-states-for-new-satellite-services/.

2 *See* Consultation at ¶ 3.1.

satellite (GSO) networks - spectrum that NGSO systems have only recently started to use. Attached as an Appendix to these Comments, Viasat submits an "Information Document" that outlines, in comprehensive detail, the issues that Viasat encourages ECTEL to consider at the market access stage, *prior to* licensing some of these mega-constellation NGSO systems.

Background on Viasat

Viasat celebrated its 35th anniversary this year. When the company started in 1986, it began as a manufacturer of components for the satellite industry, gaining significant expertise over the next several decades developing innovative satellite technologies for spacecraft, ground infrastructure, user terminals and network design. Our Viasat-1 satellite, which launched in 2011, earned a Guinness Book of World Records Award for being the highest-capacity communications satellite in the world at that time, a record we beat with the ViaSat-2 satellite in 2017 and will beat again in 2022 with the launch of our ViaSat-3 GSO Ultra-High Throughput Satellite (UHTS).

Viasat's global mission is to connect everyone, everywhere. Viasat is bridging the digital divide, allowing more people to benefit from broadband services by connecting the unconnected in underserved and unserved areas throughout the world. Our broadband services empower communities, students, and microenterprises, drive growth and connectivity, and support many new services in the areas of telemedicine, education, disaster recovery and relief, and agriculture. In addition, Viasat is a global leader in Earth Stations in Motion (ESIM) connectivity, providing service to a variety of global and regional airlines including American Airlines, Delta Airlines, JetBlue Airways, United Airlines and KLM Royal Dutch Airlines, among others. We also provide a robust maritime and land ESIM service, enabled in part by our acquisition this year of RigNet, which provides managed communications services to the energy industry, including services to over 1200 onshore and offshore oil and gas sites around the world, including across the Caribbean.

Viasat is recognized for quality satellite broadband solutions, for example, by U.S. News & World Report as one of the top internet service providers (ISPs) in the United States, by Fortune for advancing a commercial connectivity solution that has a measurable social impact, by CNET as the best satellite provider for rural connectivity in the United States, and by Fast Company's World Changing Ideas list for using satellite-connected Wi-Fi hot spots to provide broadband service where wireless infrastructure is too costly to install.

Viasat believes in fearless innovation and is finding better ways to deliver connections with increased capacity. On a global basis, Viasat currently provides satellite-powered commercial broadband services using our ViaSat-1, ViaSat-2, WildBlue-1 and ANIK F2 satellites. Among other innovations, Viasat is developing a new generation of geostationary (GSO) satellites known as UHTS satellite networks. UHTS satellite networks have many new features, including highly efficient spectrum reuse that yields enormous capacity, and smaller end-user terminals that are more readily deployed. Through this innovation, satellite networks can provide high-speed broadband to customers featuring speeds of hundreds of Mbit/s.

Viasat's next generation of ViaSat-3 spacecraft will enable more affordable, faster, and more reliable service to consumers. ViaSat-3 will consist of three satellites covering the entire world and will be a game changer in the industry in that it will provide 1 Tbit/s of capacity per satellite. We are poised to launch the ViaSat-3 satellite designed to serve the Americas region next year. We call our new satellites "ViaSat-3 class" because they represent the third generation of our innovative Ka Band broadband satellite design. They will use the entire 17.7-21.2 GHz band for downlinks (space-to-earth) and the entire 27.5-31 GHz band for uplinks (earth-to-space). Doing so provides the means to allow Viasat to provide connectivity to homes, workplaces, aircrafts, ships, ferries, trains, buses, as well as emergency response and other vehicles.

Viasat also designs, builds, and operates NGSO satellites and currently operates a satellite for a U.S. Government customer in LEO at an orbit of 575 Km and has active plans to expand its fleet with additional satellites and satellite constellations. For example, Viasat has authority to serve the U.S. market with an NGSO satellite system consisting of 20 satellites operating in medium earth orbit (MEO) and is seeking a modification to deploy 288 satellites at a lower altitude in LEO. In addition, Viasat builds many payloads and ground network components for commercial NGSO operators and is under contract with the U.S. Department of Defense to launch a high value LEO satellite that will demonstrate Tactical Data Links from space in support of the U.S. Department of Defense and Space Force. Many more such satellites are contemplated.

Technological Advancements in the Industry Improves Satellite Broadband Economics

In its Consultation, ECTEL suggests that most existing satellite broadband services experience higher latency and provide lower capacity and that NGSO LEO and medium-Earth orbit ("MEO") systems avoid some of the latency issues inherent in GSO systems. While latency is a factor that affects approximately 5% of Internet traffic (specifically real-time multiplayer video gaming and high-speed online stock trading), the primary driver for telecommunications networks remains affordability. Affordability is inevitably the key driver in improving connectivity for underserved populations across the ECTEL region.

Affordable access to quality Internet remains a challenge in many parts of the world, including in some parts of ECTEL member states' territories. Satellite technology has developed significantly over the last decade to address these concerns, by increasing the capacity in GSO satellites to reduce the cost per Gbit/s of operations of the satellites.

As noted above, one of the major changes that has been taking place within the satellite industry is the development of a new generation of Ultra High Throughput GSO satellites providing much greater capacity than previously available. As a key pioneer in the development of this technology, Viasat has been responsible for many of the improvements in satellite broadband economics in the past decade. Viasat's focus has been on creating more capacity for roughly the same cost as previous models – this is the focus that drive's Moore's Law across a variety of technology fields. This is demonstrated in Figure 1 below, which shows how each Viasat satellite (ViaSat-1, ViaSat-2, and ViaSat-3) have fueled a 500x capacity improvement and a simultaneous 400x cost reduction in the satellite broadband market, and Figure 2, which shows analysis by investment firm Morgan Stanley to compare the operating costs of a leading NGSO network against GSO systems including ViaSat-2 and ViaSat-3.

The economic and technical factors of GSO networks provide significant affordability advantages over NGSO systems. A single GSO satellite can provide constant coverage over a given country, island, or town. An NGSO network requires many satellites to do so. Further, a GSO satellite has a design life of 15-20 years or more, while LEO satellites are commonly built to de-orbit and burn up in the atmosphere after only 5 years of operation. This means the entire cost of building and launching all of the satellites in an NGSO system must be incurred 3-4 times in the same 15–20-year lifespan of a single GSO. Compounding this inefficiency, a single LEO satellite has a limited field of view (for example, at 500 km altitude, only 0.55% of the earth's surface) and spends most of its time over open water and unpopulated parts of the earth, where there are no customers for their service. This results in a huge amount of wasted capacity in an NGSO network relative to a GSO network, which is exacerbated in networks with larger numbers of LEOs at lower orbits. In contrast, a GSO UHTS satellites can see over 33% of the earth's surface, and the use of spot beams allows the satellite to focus its capacity to where the demand is.

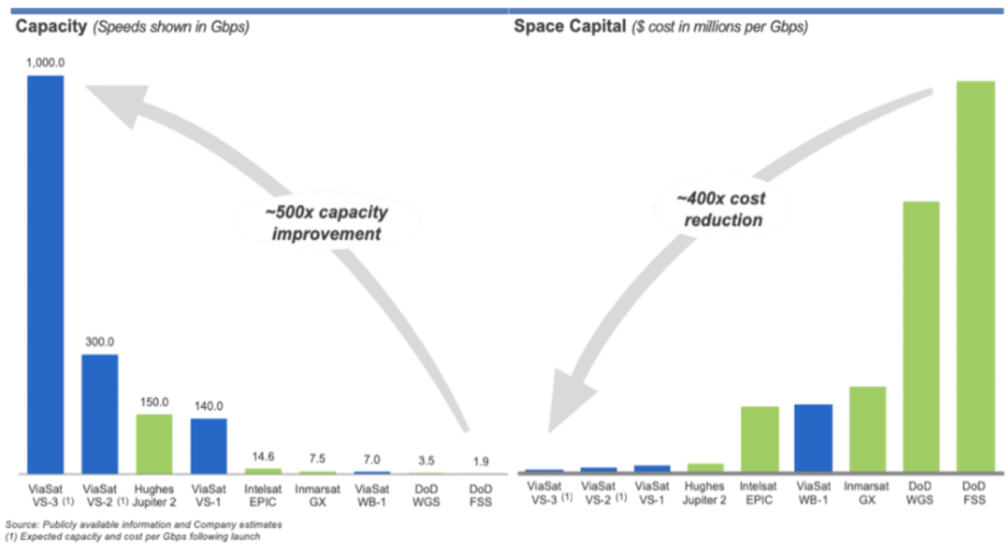

Figure 1: Capacity improvement and operating cost reduction in GSO networks in the Ka band.

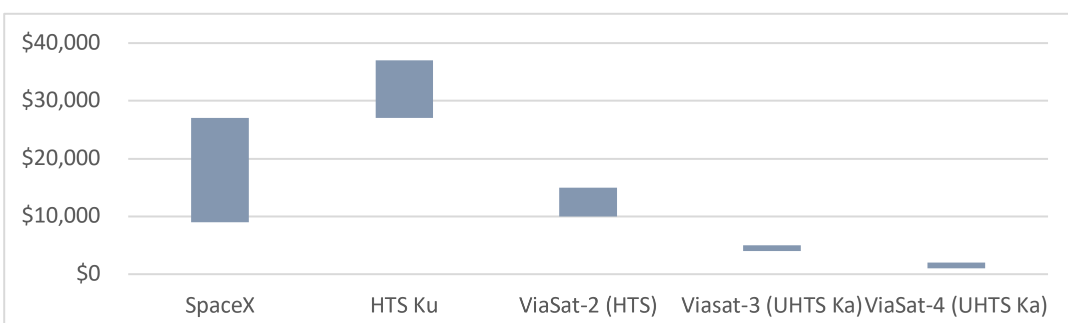

Figure 2: Operating cost comparison between NGSO and GSO networks[3].

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[3] Next Generation Ultra-High-Throughput-Satellites (UHTS) will change the economics of satellite broadband. (Source: Morgan Stanley, July 20, 2020; Source: Company Data; Note: LEO utilization assumed at 5-15% with 5 year useful life vs GEO at 75-100% with 15 year

Today's Ka band UHT GSO satellites are extremely efficient in how they use spectrum to provide innovative services with smaller user terminals than ever possible before. Taking advantage of the advancements in technology, satellites like ViaSat-3 are capable of providing more than 1 Tbit/s of total capacity each and dynamically direct capacity and coverage where and when it is most needed. And each next-generation ViaSat-4 satellite will have 5-7 times that amount of capacity. Viasat has pioneered mobile broadband services using innovative antenna designs for ESIM service to aircraft, ships, and land-based users. These services include gate-to-gate/port-to-port, high-speed broadband for communications and entertainment, cabin support, and fleet digitization for passengers and crew on aircraft and ships.

In its Consultation, ECTEL also asserts that NGSO satellite communications constellations have a distinct advantage over terrestrial networks in that they can provide reliable broadband services to remote and underserved geographic areas and also be used as a means to support emergency response services during a catastrophe. As a developer and operator of GSO, MEO and LEO satellite systems, Viasat disagrees with ECTEL's assessment that NGSO networks offer any reliability gains over other satellite technologies. For example, all NGSO terminals require the ability to simultaneously track multiple satellites in the system, which requires increased sophistication and, in many cases, moving pieces, all of which contributes to complexity and cost. GSO network terminals are fixed and less mechanically complex, which makes them ideal for emergency response situations, where they can be easily lowered in on helicopter or brought over on launches. Their lower capital and operating costs means that they are the go-to solution for a variety of emergency response situations, including by Non-Governmental Organizations (NGOs) like the Red Cross or religious relief organizations.

For example, following the tragic collapse of the Brumadinho dam in Brazil, Viasat and its partner Telebras were able to provide the first point of emergency response for the Brazilian government by installing a terminal on top of debris that had been washed away in the collapse, as seen in figure 3[4].

Figure 3: Viasat partner Telebras were first on the scene of the Brumadinho dam catastrophe, enabling government to organize and coordinate a response.

useful life; Costs do not include user terminals; SpaceX based on initial constellation of ~12k satellites costing ~$20B; ViaSat-4 annotation provided by Viasat).

4 *See:* https://www.telesintese.com.br/telebras-aumenta-capacidade-satelital-sobre-brumadinho/

ECTEL's Proposed Amendment to Its Fee Regulations

In its Consultation, ECTEL recommends (i) that the current fee structure be maintained for SES and VSAT applications for the C and Ku bands and (ii) that the current fee regulations in ECTEL Member States be amended to include two new fee subcategories: Very Small Aperture Terminal (VSAT) Other (VST Other), and Satellite Earth Station Other (SES Other). ECTEL asserts that it is making this recommendation to make an allowance "for the more modern satellite communications services such as Ka band and V band." ECTEL proposes that the fees for the "VSAT Other" and "SES Other" subcategories include an initial application fee of XCD 1,000 (USD $370) with an annual fee of XCD 12,000/frequency pair (USD $4,444).[5]

Viasat fully appreciates ECTEL's desire to adopt a regulatory framework that takes into consideration new satellite services and applauds ECTEL's efforts to conduct a comparative analysis of fees imposed in other jurisdictions (such as Trinidad and Tobago, Bahamas, Jamaica and the United States). While Viasat does not object to the imposition of a reasonable annual fee for these subcategories, Viasat believes that the proposed annual fee of approximately USD $4,500 will discourage the deployment of broadband services as well as the broad distribution of user terminals, particularly if the proposed service contemplates the potential deployment of hundreds of VSATs utilizing the Ka Band. As noted below, Viasat has deployed over 500 VSATs throughout Jamaica as part of a public-private partnership with the Ministry of Education to connect schools throughout Jamaica.

Viasat encourages ECTEL to consider the U.S. model as adopted by the Federal Communications Commission (FCC) with respect to annual fees for earth stations.[6] The annual license fee for an earth station is set at a fixed rate of USD $595 per earth station license which could include an authorization for multiple earth stations. As ECTEL referenced in its Consultation, the FCC's regulatory fees are designed to recover administrative costs. As such, they are not tied to specific spectrum usage or a specific frequency pair. For ECTEL's awareness and comparison, Viasat also notes that the European Commission on Posts and Telecom (CEPT) have largely moved to a license exemption basis for user terminals and ESIM in many satellite bands, including the Ka Band, which has had a tremendous impact on the ability of companies like Viasat to deploy thousands of terminals across many European countries including France, the UK, Germany and Spain[7].

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5 The Telecommunications (Fees) Regulations in the Commonwealth of Dominica (originally established in 2007 and amended in 2016) define a "frequency pair" as a pair of transmit and receive frequencies used in semi-duplex, and/or duplex operation. This definition is consistent across the ECTEL Member States, with a slight variation in St. Kitts and Nevis and St. Vincent and the Grenadines.

6 *See*: In the Matter of Assessment and Collection of Regulatory Fees for Fiscal Year 2021 FCC, FCC # 21-98, https://www.fcc.gov/document/fcc-adopts-assessment-and-collection-fy2021-regulatory-fees.

7 *See: ECC Decisions (05)01, (05)08, (13)01, and (15)04, inter alia.*

Satellite services can play a major role in the telecommunications and broadband infrastructure of ECTEL Member States and also advance very important public policy goals as articulated under Article 4 of the ECTEL Treaty (to promote the introduction of advanced electronic communications/telecommunications technologies and an increased range of services in ECTEL Member States) as well as various Articles of ECTEL's Electronic Communications Bill, including ensuring the overall development of electronic communications in the interest of the sustainable development of ECTEL Member States (Article 3(2)(h)) and encouraging, promoting, and facilitating the development of investment, innovation, and competitiveness in electronic communications in ECTEL Member States (Article 3(2) (j)). Viasat respectfully submits that reducing ECTEL's proposed annual fees for SES/VSAT licensing will go a long way in encouraging investment and innovation for the ultimate benefit of consumers.

Not All Broadband Services Are Created Equal

In its Consultation, ECTEL confirms that its existing annual license fee depends upon the nature of the licensed service. Viasat encourages ECTEL to maintain flexibility in the application of any current or proposed fees as certain services may warrant special consideration. For example, the provision of emergency services during a disaster (hurricane, volcano, etc.) may warrant a waiver or significant reduction of fees to allow for the immediate provision of needed connectivity for the benefit of the government and citizens of ECTEL Member States.

Viasat offers the following examples as case studies where we have provided critically needed services for the benefit of communities and in furtherance of government initiatives to ensure that communities are connected. In such instances, fees for SES or VSATs have either been waived or significantly reduced.

Viasat's Community Internet Program

Viasat recognizes that nearly half of the world does not have access to the internet. As such, Viasat's Community Internet Program is not an ancillary afterthought but is an important part of Viasat's DNA, demonstrating our commitment to connect unserved and underserved communities and to provide high-quality satellite internet access to those who are in most need. Viasat supports digital inclusion through this initiative by making affordable, high-speed internet accessible to everyone in rural communities worldwide.

Viasat launched its Community Internet service in Mexico in early 2016. Since then, we have connected thousands of rural communities across each of the country's 32 states, providing internet access to nearly two million people who are within walking distance of one of our Community Wi-Fi hotspots. The regulatory fee framework in Mexico allowed this initiative to become a reality, in particular the ability to ubiquitously deploy terminals under a single blanket license.[8] This reduced the costs associated with each terminal's deployment and allowed Viasat to focus on improving the affordability of the service for

[8] *See:* In Mexico, Satellite and Wi-Fi Come Together to Bring Internet to Remote Areas, April 16, 2018; https://www.viasat.com/about/newsroom/blog/how-satellite-and-wi-fi-come-together-to-bring-internet-to-remotest-mexico/

those left behind by traditional terrestrial networks. We are proud that Fast Company[9] and Fortune[10] Magazine both highlighted this initiative as a world changing idea.

In addition, Viasat encourages special consideration in cases where connectivity to unserved or underserved areas in ECTEL Member States is pursued as a major government initiative. This is a core focus of Viasat's Community Internet Program which, as outlined below, has been deployed in a number of jurisdictions for a number of years.

Connecting Schools in Jamaica

Early on during the outbreak of the COVID-19 pandemic, Jamaica, like many countries, faced significant challenges in ensuring that all schoolchildren and teachers across the country could access the Internet to keep school in session and to avoid a deepening of the educational digital divide. Satellite broadband was clearly the most useful technology for reaching many of the educational sites the government wanted to connect. However, one obstacle to the deployment of satellite services was a VSAT licensing regime that did not reflect the recent advances in high-throughput satellites, and the global trend towards ubiquitous deployment of user terminals. In particular, the Ministry of Education wanted to initiate this project with the deployment of 100 VSAT terminals to schools in hard to reach parts of the country where terrestrial networks have not been successfully deployed.

Partnering with a local ISP, ReadyNet, to acquire HTS capacity from Viasat, the Ministry recognized that the annual per-terminal VSAT fee totaling approximately USD $4,500 (including both spectrum and regulatory fees) was a significant obstacle to the financing of the connectivity program and ensuring connectivity to schools across Jamaica.

After a discussion amongst stakeholders, the Ministry of Science, Energy and Technology, together with the Spectrum Management Authority, undertook a rapid review and evaluation of the VSAT licensing regime, and opted to update the license fees to better reflect global best practices. This led to a significant reduction in fees for the project that paved the way for the Ministry of Education's program to launch. All in all, fees were reduced to roughly USD $5 per year per VSAT terminal (a reduction of more than 99%).

As a direct result of the reduction of these fees, over 500 schools have been connected through this initiative.[11] Although the program is primarily focused on schools, it demonstrates what is possible using satellite to bridge the digital divide in the Caribbean region.

The decision to use Ka Band (17.7-21.2 GHz downlink, 27.7-31 GHz uplink) HTS technology gives each school site a 25 Mbit/s download and 5 Mbit/s upload speed, sufficient for high-definition video conferencing, and multiple video streaming services to operate simultaneously.

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9 *See:* https://www.fastcompany.com/90490840/heres-how-one-company-is-delivering-the-internet-to-remote-villages

10 *See:* *https://fortune.com/change-the-world/2019/viasat/*

11 *See:* Viasat Delivers High-Speed Satellite Internet to Jamaica, October 1, 2019; https://www.viasat.com/about/newsroom/blog/viasat-delivers-high-speed-satellite-internet-to-jamaica/.

Government Sponsored Wi-Fi in Brazil

Since late 2018, Viasat has collaborated with Brazil's state-owned telecommunications company Telebras to provide internet service to over 15,000 schools, health clinics, hospitals and government facilities across the country under the e-government initiative of the Ministry of Science, Technology, Innovation and Communications (MCTIC), known as Governo Eletrônico - Serviço de Atendimento ao Cidadão (GESAC). This initiative has recently been doubled by the Ministry of Communications and will reach over 30,000 locations in the next few years.

All of these above referenced initiatives have been accomplished through public-private partnerships where regulatory frameworks have allowed for flexibility in the waiver or imposition of reduced fees to allow for an aggressive roll out of affordable services to consumers, many of whom are first time users.

Viasat would welcome the opportunity to embark on similar initiatives in ECTEL Member States whether the project may be in Roseau, Saint George's, Basseterre, Castries, Kingstown or in other areas within the ECTEL Member States where a more critical need for connectivity may exist. However, the fees for SES/VSAT licensing as currently contemplated by the Consultation would make such a project very difficult to pursue.

Emergency Response

A significant benefit of satellite communications is the ability to immediately support recovery efforts during times of disaster. Sadly, the likelihood of ECTEL Member States and the rest of the Caribbean region experiencing natural disasters on an annual basis is real. Hurricanes and other natural disasters such as La Soufrière Volcano in St. Vincent and the Grenadines this year demonstrate how quickly these catastrophic events can happen. Viasat agrees with ECTEL that satellite systems can provide significant support in these situations. With its relief efforts in the Bahamas during Hurricane Dorian as well as most recently in Louisiana during Hurricane Ida, Viasat understands first-hand what is needed to quickly deploy much needed services. Under such circumstances, Viasat respectfully submits that consideration should be given to the waiver or significant reduction of fees to encourage the prompt provision of connectivity.

NGSO Licensing Requires Thoughtful Conditions

Viasat recommends that ECTEL Member States carefully review the nature of the service to be offered and where justified, ensure that ECTEL's SES/VSAT licensing regime reduces barriers to the deployment of satellite technologies by (i) ensuring that SES/VSAT licensing and spectrum fees are waived or significantly reduced; (ii) enabling blanket licensing for user terminals; and (iii) examining the role that satellite broadband can play in promoting national broadband plans to advance the digital transformation of communities and economies. Maintaining flexibility in the application of fees to a particular service will be key, particularly in advancing public/private partnerships for the benefit of communities.

As noted above, Viasat takes this opportunity to explain why NGSO mega-constellation systems present significant and unanticipated threats to GSO systems and urges ECTEL to take appropriate action, at the market access stage, *prior to* licensing a mega-constellation NGSO system.

Historical Context

The potential for disruption to GSO networks by co-frequency NGSO systems is well-known and is what led to the development of certain equivalent power flux density (EPFD) limits 20 years ago in some frequency bands based on technologies and systems that were designed decades ago. The twenty-year old framework for NGSO systems that has been developed at the International Telecommunication Union (ITU) has several well-understood shortcomings and the review process for NGSO ITU filings cannot be relied upon to ensure interference-free operations where NGSO systems are involved. In short, current ITU Radio Regulations for the protection of GSO networks from NGSO systems are a patchwork, particularly in the Ku and Ka bands.

Indeed, the ITU has itself stated that compliance with the NGSO EPFD limits is the responsibility of administrations in cases where the ITU's EPFD modelling software cannot sufficiently model a particular NGSO system. It also remains the responsibility of administrations in determining whether NGSO systems satisfy EPFD limits during actual operation. Services to ECTEL Member States will be significantly degraded by interference if these issues are not resolved *before* NGSO systems are licensed to operate in ECTEL Member States.

Technological Developments

Both NGSO system and GSO network characteristics have evolved significantly over the last 20 years. NGSO system EPFD limits were largely finalized in 2003 at a time when a 288-satellite NGSO system was considered large and GSO networks were capable of achieving only relatively low throughput (e.g., 1 Gbit/s). Today's NGSO systems include thousands, or tens of thousands, of satellites in a variety of low Earth orbits (altitudes and inclinations). Even if a GSO network earth station is in an area illuminated by a single NGSO satellite main beam, it will receive radiation from 100's (or often 1000's) of NGSO satellite system beam sidelobes. In addition, significant questions exist about how today's NGSO system operators will be able to both calculate and actually manage the cumulative interference impact of the countless sidelobes created by satellite antenna beams and the sidelobes and backlobes created by NGSO user terminals.

Recommended License Conditions

It is important to note that ECTEL cannot solely rely on the ITU framework to effectively deal with all concerns impacting NGSO services provided to ECTEL Member States. Software-based EPFD validation through the ITU process is only as accurate as the inputs provided by NGSO operators.

While ITU-R recommendations have been developed to assist administrations in measuring aggregate EPFDs, they are not effective in measuring single entrant EPFDs once multiple systems have become operational, as it is impossible to differentiate between emissions from the individual systems. In order to mitigate the risk of interference to GSO networks licensed by or serving ECTEL Member States, it is therefore critical to address this threat at the licensing stage, rather than hoping it can be addressed after NGSO operations commence.

Therefore, Viasat submits the following recommended licensing conditions for ECTEL's review. These are based on our global monitoring of trends and best practices, as well as our in-depth technical review of NGSO systems as both a manufacturer and operator of GSO and NGSO networks.

- **Temporary and Limited**:
  - ECTEL should consider limiting the duration of an NGSO license to one year, to allow for review on a periodic basis of the potential interference caused by the operator and should allow smaller batches of the system's satellites to serve the region in the first years. For example, it may be useful to limit a large NGSO system to only 2,000 satellites to serve ECTEL in the first year, and that number could be raised upon the annual review, if conditions for non-interference and responsible network management are met.
  - ECTEL should conduct the annual review together with the Eastern Caribbean Aviation Authority and the Latin American and Caribbean Space Agency (ALCE), which each have areas of demonstrable competence in managing the orbital and space safety considerations inherent in NGSO constellation operation. Together, these agencies can assess the results of the NGSO system's implementation progress, and its impact on orbit safety, spectrum use, and competition, after which ECTEL will either maintain, reduce, or increase the number of satellites that Starlink can use for its operations in the ECTEL region and otherwise may adjust the license terms.

- **Angular Separation**:
  - The NGSO system must maintain an 18-degree GSO Arc avoidance angle when serving ECTEL nations, so as to avoid interference to GSO networks which provide much of the emergency response, government communications, ESIM and cellular backhaul operations that are critical to ECTEL member states.
  - A given NGSO system may operate only with 1/n of the look angles in ECTEL, where *n* is the number of NGSO systems licensed to serve ECTEL in the same frequency band and it must coordinate in good faith and in advance with other NGSO systems so that all *n* look angles may be used to serve ECTEL by those different NGSO systems.

- **Ensuring non-interference:**
  - An NGSO system may not cause unacceptable interference into GSO networks and may not claim interference protection from GSO networks. The system must have an operational feature that allows an immediate interruption of the radio frequency emissions to ensure satisfaction of this requirement and must cease emissions upon notice of unacceptable interference.
  - The NGSO sytem operator may not use more than one satellite beam for satellite transmissions on the same frequency in the same or overlapping areas at a time in the downlink bands.

    - If aggregate interference to a GSO network from signals transmitted by multiple NGSO systems is detected, and it is not possible to identify the NGSO system generating the interference, ECTEL should require that all NGSO operators shall cooperate with the operators of such other NGSO non-geostationary systems, taking the technical measures necessary to eliminate the interference.

- **Station keeping**: In order to ensure robust competition and safe use of scarce orbital resources, ECTEL should require that NGSO operators may operate in orbital altitudes as licensed by their filing administrations, but must maintain an orbital tolerance of +/- 2.5 km for the apogee and perigee of each satellite, and a 0.5° tolerance for each orbital inclination it employs in order to ensure other NGSO systems may access the shared LEO space.

- **Orbital safety reporting**: ECTEL should require that a licensed NGSO operator must provide to ECTEL, every 6 months, a report on the following, which will be used to make determinations on its safety practices in support of a possible extension of its license:
    - Number of satellites launched.
    - Total number of its satellites in orbit that cannot be reliably maneuvered.
    - The failure rates of its satellites during that 6-month period; the causes of such failures and the remedial action(s) taken; the number of conjunctions and avoidance actions during that 6-month period, and any difficulties in the collision avoidance process and measures taken to address them.

- **ITU Filings:** ECTEL should consider that all NGSO system filings under which an NGSO operator's system operates are viewed as a collective, and the system must operate such that it does not exceed the limits established for a single NGSO system under a single ITU filing. This avoids the potential to game the EPFD limits by having "multiple entry" filings that could lead to overwhelming EPFD interference.

- **Modifications to the network:** ECTEL should require than an NGSO operator may not modify the radiofrequency characteristics of their system or increase the mass or cross-sectional area of its individual satellites, without prior consent from ECTEL.

- **Reporting and System Modifications**: ECTEL should require that an operator must provide the following information to ECTEL as part of the license application and must report the same on an annual basis. This information will also be used to assess the system's impact on the spectrum and competitive environments in ECTEL:

    - Number of total beams on each satellite serving ECTEL
    - Number of co-frequency beams on each such satellite
    - Number and size of frequency channels on each such satellite
    - The number of satellite beam used for transmissions on the same frequency in the same or overlapping areas at any given time
    - How the system avoids interference to GSO networks created by earth station and satellite sidelobes, and earth station backlobes, particularly when phased array antennas are employed

Conclusion

Viasat reiterates its appreciation to ECTEL for providing an opportunity to submit comments to this important Consultation. Viasat welcomes the opportunity to provide any additional information in the future and update ECTEL on relevant developments within a very dynamic satellite industry that continues to evolve on a daily basis.

Respectfully submitted,

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Appendix: Regulation of NGSO systems, as originally submitted to the 37th meeting of CITEL's PCC.II (5-9 April 2021)

37 MEETING OF PERMANENT	**OEA/Ser.L/XVII.4.2.37**
CONSULTATIVE COMMITTEE II:	**CCP.II-RADIO/doc. 5320/21**
RADIOCOMMUNICATIONS	**22 March 2021**
April 5 to 9, 2021	**Original: English**
Virtual meeting	

REGULATION OF NGSO SYSTEMS

(Item on the Agenda: 3.4)

(Information Document submitted by Viasat)

Impact on the sector:

This document provides critical information related to the licensing of, or grant of market access to, constellations consisting of thousands of satellites in Low Earth Orbit (LEO). It urges CITEL Administrations considering requests for such authority to address critical issues of preclusive effects on others' use of limited and shared spectrum and orbits, radio spectrum interference, and environmental impact.

Executive Summary:

The space ecosystem is changing rapidly. New geostationary (GSO) satellite systems are being designed and deployed with exciting new broadband capabilities that promise broadband connectivity opportunities for all. At the same time, LEO has become more readily accessible, and new low cost launch options are becoming available from multiple sources. LEO constellations are a way for all nations to access space, and facilitate augmentation of other national telecommunications network resources such as GSO satellites, wireless networks, data centers, and cloud centers. All nations can create new high technology jobs and participate in global efforts around LEO satellite system design, manufacture, operation, and network planning.

These opportunities are under threat by a few mega-constellations consisting of thousands or tens of thousands of satellites in LEO. The world can support only a finite number of satellites in LEO orbits. A few individual companies are attempting to seize and monopolize those limited orbital resources before the rest of the world understands those limits. Because of the very large numbers of satellites involved, LEO mega-constellations present growing concerns about: (1) interference to GSO networks; (2) interference to, and access to the same orbits by, other LEO systems; (3) space safety; and (4) environmental impact on Earth's atmosphere and skies. Below, Viasat provides background on these critical and time-sensitive issues as well as actionable recommendations for CITEL Administrations.

Viasat submits this information paper as a matter of urgency on recent developments that require immediate attention in order to ensure that (i) satellite-delivered broadband remains viable in CITEL Administrations, and (ii) the actions of a few do not damage CITEL Administrations' skies or the availability of existing or future competitive broadband options.

Viasat is dedicated to connecting the citizens of CITEL Administrations with affordable, high quality broadband services across the region. Viasat's satellites are designed to offer broadband services through ubiquitous user terminals with broadband speeds of up to 100 Mbit/s over many CITEL Administrations, including locations in cities and rural regions that are not served by traditional terrestrial services. For millions of citizens in CITEL countries living outside the "connected" portions of large cities, the broadband services of Viasat and of other geostationary ("GSO") satellite service providers are their only option to get broadband communication services at reasonable prices with good quality and in a timely fashion. Viasat will further improve the broadband available in the Americas next year, when we launch our new ViaSat-3 satellite. This satellite has more capacity than any other satellite launched to date (over 1 Terabit per second) and enables services and speeds never before possible.

At the same time, low earth orbit (LEO) has become more readily accessible, and new low-cost launch options are becoming available from multiple sources. LEO constellations can augment other national telecommunications network resources such as GSO satellites, wireless networks, data centers, and cloud centers. All CITEL Administrations can create new high technology jobs and participate in global efforts around LEO satellite system design, manufacture, operation, and network planning. At the same time, they can maintain national sovereignty over the use of space to serve their territories.

These significant opportunities are under threat by a few mega-constellations consisting of thousands or tens of thousands of satellites in LEO. LEO is a shared and limited resource – a "commons" that must be protected and accessible to all. New research and modeling from multiple academics, space companies, and even the United States Federal Communications Commission, indicate that the world can support only a finite number of satellites in LEO orbits. Leading experts also recognize that LEO mega-constellation operators may not have the economic incentive to protect these shared resources. In fact, a few individual companies currently are attempting to seize and monopolize those limited orbital resources before the rest of the world understands those limits, and before the environmental consequences have been fully studied and the harms are mitigated. Moreover, many recent technological advances have eliminated the high cost of access to space that once fostered a responsible space ecosystem and limited the number of objects launched into space. The growing trend toward deploying huge numbers of mass produced, and economically expendable LEO satellites to stake exclusive claims to the best orbital assets is leading the world to a very dangerous place that also threatens the atmosphere on Earth and a dark and quiet sky that is critical for scientific research.

Previously, the rules to manage the risks were adequate. That is no longer the case. Today, self-interest and the public good are quickly diverging, as the cost of failure to an individual actor is far, far less than the collective risk of that failure.

In fact, leading international organizations call these mega-constellations "game changers" that can create a new "ecological tipping point" when it comes to space junk and pollution. As a result, they have released calls for action that include addressing these threats at the national level. Indeed, as a just-released book explains,[12] the launch of such a "mega-constellation" from one jurisdiction has profound impacts on many other jurisdictions around the world.

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[1] *Losing the Sky - The threat from satellite mega-constellations, why it matters, and what we can do about it*, Andy Lawrence with assistance from Jonathan McDowell, Robert J. Antonucci, Photon Productions, February 8, 2021, at page 5.

> "The new sky pollution - swarms of satellites - is even more global. When you a launch a satellite in Low Earth Orbit, within an hour and a half it has circled the globe. You may launch from Florida or Kazakhstan, but you are instantly polluting Namibia and France."

The same is true for pollution in CITEL Administrations caused by other Administrations' LEO mega-constellations. It is critical that CITEL Administrations address these types of issues themselves in considering market access requests for LEO mega-constellations, and before granting their share of limited orbital resources to individual foreign companies. In particular, CITEL Administrations should consider, before granting market access, how a LEO mega-constellation can (i) constrain CITEL Administrations' access to shared and limited orbits and spectrum, including for national satellite programs in telecommunications, earth observation and other scientific endeavors, (ii) limit consumer choice and competition in CITEL Administrations, and (iii) disrupt a dark and quiet sky and impair important scientific research, and (iv) pollute the environment.

As discussed in more detail below, the threats created by LEO mega-constellations include:

- Generating unacceptable levels of interference into GSOs and harming a variety of important GSO-based services.
- Constraining the ability of other NGSO satellites to provide competitive services by blocking access to critical shared spectrum and orbits.
- Creating collision risk and new space junk that impair access to space by others who seek to serve CITEL Administrations.
- Polluting our atmosphere, affecting the health and well-being of CITEL countries' citizens.
- Polluting the dark and quiet sky, affecting science-based astronomy (optical and radio) and other local activities in CITEL Administrations, like astrophotography and star gazing.

Viasat urges CITEL Administrations to evaluate, at the market access stage, ways to protect the availability of satellite broadband service offerings for CITEL country citizens and address the potential harms from LEO mega-constellations to the Americas' environment. This should include full consideration of these issues when considering market access applications, adopting suitable mitigation measures where market access is awarded, and imposing conditions that ensure the actual operation of any LEO mega-constellation is consistent with the considerations underlying any grant of authority to serve CITEL Administrations.

REGULATION OF NGSO SYSTEMS

1. Constraining NGSO Interference into GSO networks.

Newly introduced LEO mega-constellations can block other satellite operators from interference-free access to the spectrum they would otherwise share. Under Number 22.2 of the International Telecommunication Union (ITU) Radio Regulations, systems of NGSO satellites (including those in LEO) "shall not cause unacceptable interference to … geostationary networks in the fixed satellite service."

Even a single LEO mega-constellation has the potential to cause harmful interference into multiple GSO networks, resulting in significant degradation and capacity losses for GSO networks that would serve CITEL Administrations. Multiple NGSO systems operating simultaneously pose an even greater risk to those GSO networks. This can impair the provision of critical GSO-based services across the Americas including commercial and national programs (*e.g.*, Mexsat, Brazil's SGDC-1, Bolivia's TK-1, ARSAT) in CITEL Administrations.

Today's very high throughput GSO satellites are extremely efficient in how they use spectrum at the GSO arc, employing low total satellite receiver noise temperatures and high satellite receive antenna gains, to provide innovative services with smaller user terminals than ever possible before. Ensuring that those capabilities are unaffected by LEO mega-constellations, as the ITU mandates, requires mega-constellations to limit the amount of unwanted energy they emit in the direction of those GSO networks, in the form of main beams and sidelobes from their satellites and their earth stations.

One way to ensure compatibility with GSO networks (as the ITU requires) is for LEO mega-constellations to maintain a suitable level of angular separation from the GSO arc, with the requisite angle depending on the particular attributes of that mega-constellation. Certain LEO mega-constellation operators have not committed to do so across all of the frequency bands they intend to use. Notably, maintaining adequate angular separation imposes virtually no constraint on LEO system capacity.

Moreover, serious questions remain about precisely how certain LEO mega-constellations will operate, which directly affects the required level of angular separation. That is, one mega-constellation operator appears to be relying on multiple ITU filings for the same NGSO system, so that it can impermissibly aggregate multiple so-called "single entry" EPFD limits and thereby generate more interference toward GSO networks than otherwise permitted. In addition, it has not been explained why, when a LEO mega-constellation is designed to have many dozens of its satellites in sight of a given location on Earth at any given time, only one single co-frequency satellite will illuminate that location, and only that single illumination will contribute to interference into GSO networks at that location. Nor has anyone explained how a LEO mega-constellation operator will be able to both calculate and actually manage the aggregate interference impact of the many millions of sidelobes created by millions of user terminals and dozens of beams on its many thousands of satellites. Furthermore, the aggregate impact on GSO networks from the operation of multiple NGSO systems would have to be limited and apportioned among these multiple systems in both the uplink and downlink directions.

Finally, some NGSO operators are actively trying to weaken, in the ITU study process, the existing ITU rules that define certain protections they must provide GSO networks. And this does not even consider that the existing rules were not developed to address the new LEO mega-constellations or their impact on today's GSO networks.

Viasat urges CITEL Administrations to ensure that LEO mega-constellations maintain adequate angular separation from the GSO arc and also demonstrate precisely how they will operate to avoid creating an aggregate interference problem for GSO networks by illuminating a location with multiple beams from multiple satellites and the many millions of sidelobes created by millions of user terminals and the dozens of beams on each of its many satellites.

2. Facilitating Equitable NGSO-NGSO Spectrum and Orbital Sharing

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

This threat to NGSO spectrum sharing arises because mega-constellations will "blanket the sky," causing many in-line interference events limiting and sometimes completely blocking other NGSO systems from sharing the same spectrum. LEO mega-constellations will rarely experience this problem themselves because their far greater number of satellites that block spectrum use by smaller NGSO constellations provides them with alternative communications paths where the same spectrum remains available to the mega-constellation.

The spectrum-preclusive effect of these LEO mega-constellations is depicted in the following table, which shows the probability of satellites in NGSO System B blocking all of the satellites in NGSO System A. Three constellation sizes are considered for each system: 300, 3,000, and 30,000 satellites. Typical orbital parameters were used, and the user terminal was modelled at a representative location of 19.3° N, 99.1° W (Mexico City, Mexico), a central location within the Americas, for CITEL Administrations' reference, for the purposes of this submission. Several observations can be made:

- A 30,000 satellite NGSO system will blanket the sky, blocking all other constellations, including other similarly sized constellations from serving Mexico.
- Even 3,000-satellite NGSO systems have a significant blocking effect on many other constellations cutting approximately 1/3 the capacity of a 300-satellite system serving Mexico.
- Conversely, 300-satellite NGSO systems never block 3,000 or 30,000-satellite NGSO systems.

	NGSO System B		
NGSO System A	300 Satellites	3,000 Satellites	30,000 Satellites
300 Satellites	2.7%	31.2%	100%
3,000 Satellites	0%	18.5%	100%
30,000 Satellites	0%	0%	100%

Probability that NGSO System B blocks a location from service by NGSO System A

This dynamic has the perverse effect of incentivizing a race in which LEO mega-constellations deploy many more satellites than actually needed, utilizing large numbers of spectrally-inefficient satellites and rejecting reasonable approaches that otherwise would enable spectrum sharing among all NGSO system types – even those operating at other altitudes. This would distort markets and leave only one or two LEOs with the ability to serve a given CITEL Administration, foreclosing competition. The threat to orbital sharing exists because LEO orbits are limited, and as leading experts recognize[13] LEO mega-constellation

[13] *See* https://www.theverge.com/2021/1/27/22251127/elon-musk-bezos-amazon-billionaires-satellites-space.

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

Viasat urges CITEL Administrations to work with like-minded countries around the world to develop a mechanism to allocate LEO satellite counts, orbital trajectories and spectrum fairly among all global nations. Viasat also urges CITEL Administrations, in granting market access, to ensure equitable access to the same spectrum by multiple NGSOs, and also ensure equitable access to shared and limited NGSO orbits. Among other things, LEO mega-constellation operators should be required to operate their satellites with suitable orbital tolerances to enable others to share the same orbits.

To facilitate avoiding interference with both NGSOs and GSOs, LEO mega-constellation operators should be required to provide sufficient technical details to enable an assessment of how all other satellite systems can share the same spectrum, including:

1. Earth station and satellite transmit power density;
2. Minimum angle of separation from the GSO arc;
3. Off-axis gain and EIRP density mask for earth stations (gateways and user terminals) and satellite antennas;
4. Identification of whether the earth stations are user terminals or gateways and how many of each class will be deployed within the CITEL Administration;
5. Number of satellites, orbits employed, orbital tolerance and other orbital characteristics;
6. Number of total beams and number of co-frequency beams on each satellite; number and size of channels on each beam; and
7. Number of co-frequency satellites serving a location on the Earth in the uplink direction and in the downlink direction.

3. <u>Avoiding LEO Mega-Constellations Polluting Space</u>

LEO orbits have become increasing littered with space junk: "The most crowded section is between 500 and 1000 km up. It's the densest region[] of space."[14] The launch of thousands, or tens to hundreds of thousands, of mega-constellation satellites into LEO increases the risk of collisions in these crowded orbits. As the Organization for Economic Cooperation and Development (OECD) recognizes[15], suitable measures must be put in place now, before it is too late, to prevent a so-called "tragedy of the commons."

The rush to fill space with expendable satellites made with off-the-shelf parts creates situations where far too many of the satellites in these mega-constellations are failing before their planned end of life, and before they safely can be deorbited. When they fail and lose maneuverability, these satellites cannot

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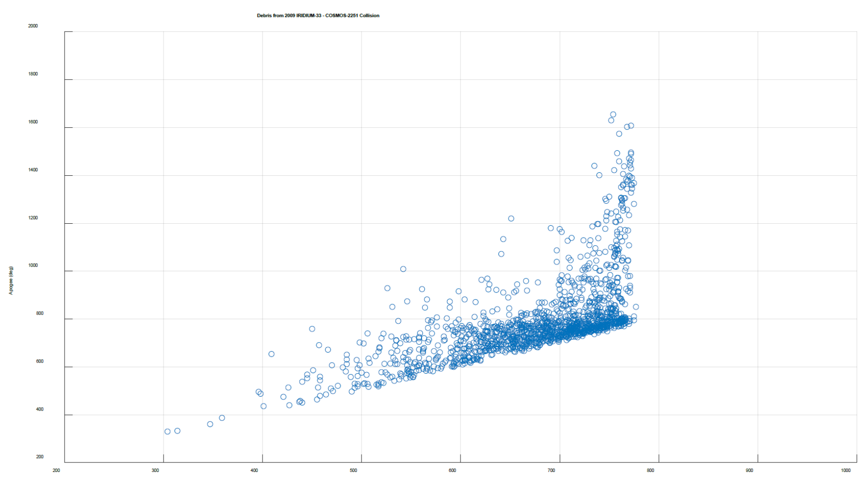
[14] Kessler Syndrome: *What Happens When Satellites Collide,* https://asherkaye.medium.com/kessler-syndrome-what-happens-when-satellites-collide-1b571ca3c47e.

[15] Organisation for Economic Co-operation and Development (OECD*), Space Sustainability: The Economics of Space Debris in Perspective,* OECD Science, Technology and Industry Policy Papers, no. 87 (April 2020): 7, 18, 26. https://read.oecd-ilibrary.org/science-and-technology/space-sustainability_a339de43-en#page1.

avoid collisions with other satellites or with space junk. And when they do collide, the resulting fragmentation can send clouds of shrapnel-like space junk hundreds of kilometers in each direction. This space junk can disable or destroy other satellites that are critical for connectivity, mapping, weather and defense purposes – and this space junk can persist for decades and even a century or more, making access to space riskier and more expensive for others.

A well-known example of a collision in LEO that was not avoided occurred in 2009 between an active Iridium satellite and a defunct Russian COSMOS satellite, which created 2,294 new trackable pieces of space junk, 1,396 of which still remain in orbit 12 years later. Again, the unprecedented increase in the number of mega-constellation satellites in LEO dramatically increases the probability of these types of collisions.

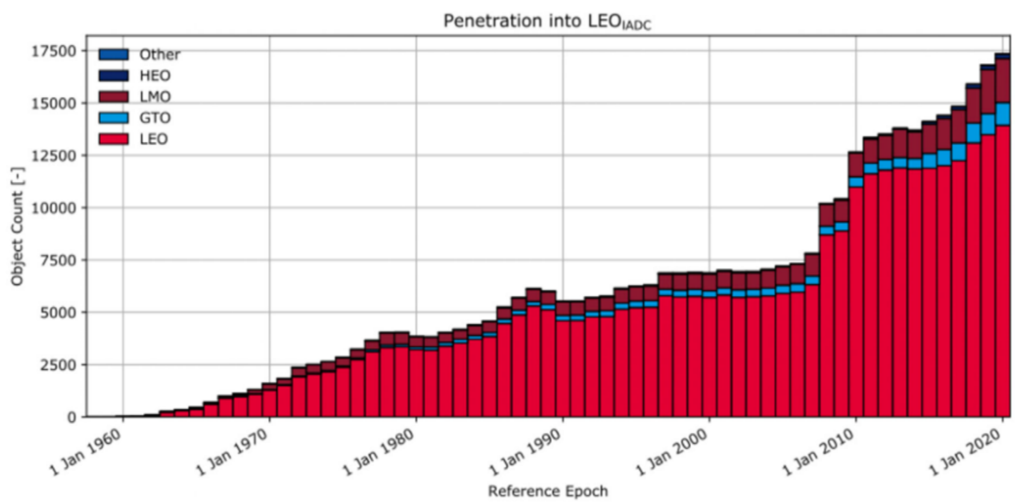


Spread of Space Junk from Iridium-33/Cosmos-2251 Collision

As reflected in data released by the European Space Agency (ESA), space junk produced by one collision continues to collide with itself, generating even more space junk, and further increasing the likelihood of collisions in an ever-evolving orbital environment. The following figure from the ESA depicts the growing amount of space objects in LEO, even before the introduction of mega-constellations.[16] A significant portion of recent increases is attributable to LEO satellites themselves, as well as the fragmentation of those satellites after collisions.[17]

[16] European Space Agency Space Debris Office, *ESA's Annual Space Environment Report* (2020): 16.

[17] Ibid 13.



The risks associated with two LEO mega-constellation satellites (or a mega-constellation satellite and a large piece of space junk) crossing each other's orbital planes is particularly significant because of:

- The large amount of energy that would be released when objects collide at thousands of kilometers per second at the intersection of their orbital paths;[18]
- How a significant fraction of the resulting space junk would periodically cross the orbital planes of the mega-constellation involved in the collision; and
- How the resulting space junk would spread to other orbit altitudes (as shown in the example above).

It is critical that CITEL Administrations, when considering a grant of market access for LEO mega-constellations, consider the aggregate collision risk over the entire term of exploitation, considering all of the many thousands of satellites and their replacements that could be deployed in a mega-constellation over that term. It is also essential to examine:

- The risks during the entire period each satellite in a LEO mega-constellation remains in orbit, at all of the orbits it may populate during its orbital lifetime (injection, operations, and post mission disposal);
- The increased risk of collisions due to known changes in the orbital environment (additional satellites being launched, not just the environment as it existed in the past);
- The risk of collisions with all sizes of space objects (not just those ≥ 10 cm and ≤ 1 cm);

[18] R. Thompson, *A Space Debris Primer,* Crosslink (Fall 2015), at 5 ("Most conjunctions converge at about a 45-degree angle, which results in a relative velocity of approximately 10 kilometers per second—ten times faster than a rifle bullet. At such velocities, the danger to satellites and space-based systems becomes obvious. The kinetic energy of even a small particle at these speeds can do tremendous damage.").

- The continued reliability of critical command and propulsion capabilities needed to allow satellites to maneuver to try to avoid collisions as long as they remain in orbit;
- The risk of intra-system collisions within any of these LEO mega-constellations (and particularly when their satellites fail); and
- Known risks with large numbers (potentially millions per year) of expected conjunctions between mega-constellations and other space objects (*e,g*., large numbers of maneuvers to avoid some collisions creates other collision risks; low probability conjunctions not avoided add up to much larger collision risks with very large numbers of conjunctions).

If LEO mega-constellations are allowed to continue to deploy without a full and complete analysis of these issues, and the adoption of suitable mitigation measures, competition and innovation in space may come to a standstill. The OECD calls the deployment of LEO mega-constellations a "game changer" and warns of the prospect for a never-ending spiral of collisions that eventually renders LEO unusable and possibly impenetrable — foreclosing access to and innovation in space for generations.[19]

Some LEO mega-constellation operators try to downplay these significant risks, by focusing on the risk associated with a single satellite, and not considering what can happen over the entire term of exploitation when thousands of satellites are operated at varying altitudes. That approach ignores the simple fact that collision risk scales with constellation size. In other words, it ignores the additive risk from each satellite in a LEO mega-constellation and the unlimited number of replacements that could be launched over the entire term. This approach would effectively sanction catastrophic collisions occurring very frequently, as depicted below:

# of Satellites in Orbit	Allowed Mean Time Between Collisions in Years (Days)
1,000	5
5,000	1
10,000	0.5 (180 days)
50,000	0.1 (36 days)
100,000	0.05 (18 days)

Table A: Collision Risk Scales with Constellation Size[20]

[19] Organisation for Economic Co-operation and Development (OECD), *Space Sustainability: The Economics of Space Debris in Perspective*, OECD Science, Technology and Industry Policy Papers, no. 87 (April 2020): 7, 18, 26. https://read.oecd-ilibrary.org/science-and-technology/space-sustainability_a339de43-en#page1.

[20] Note: Calculations are based on 5-year satellite design life, and an application of the one-in-1,000 collision risk standard commonly used in the past for single-satellite risk scenarios.

Some LEO mega-constellation operators also try to downplay the risks by claiming that they will deploy autonomous collision avoidance mechanisms. But the effectiveness of those capabilities depends entirely on each of their satellites being able to reliably and effectively maneuver for as long as it remains in orbit—after injection, while at operational orbit, and during post-mission disposal. Satellites that fail or degrade such that they no longer can be reliably maneuvered cannot avoid collisions—with each other, with satellites in other systems, or with the large and growing amount of space junk. Thus, the deployment of unreliable LEO mega-constellation satellites presents undue risks to space and everyone who seeks to utilize space.

Of great concern are the cost/safety tradeoffs being made today in mega-constellation designs that value large numbers of low-cost, economically expendable satellites over constellations with fewer and more reliable satellites. Making that tradeoff reduces the likelihood of successfully maneuvering to avoid the inherent risk of collisions. It also means that even more satellites in the LEO mega-constellations need to be launched than are necessary leading to the other harms discussed below.

Considering that the ability to mitigate collision risk depends highly on how LEO mega-constellations actually are deployed and operated, Viasat urges CITEL Administrations, when evaluating a mega-constellation's market access application, to consider the aggregate collision risk over the entire term of the license, considering all of the many thousands of satellites and their replacements that could be deployed in a LEO mega-constellation over that term. Viasat also urges CITEL Administrations to conduct an evaluation of the entirety of the collision risk for the constellation as a whole, taking into account:

- Collision risk at all of the orbits a satellite may populate during its orbital lifetime;
- Collision risk due to known changes in the orbital environment;
- Collision risk with all sizes of space objects (not just those ≥ 10 cm and ≤ 1 cm);
- The reliability of critical satellite capabilities needed to avoid collisions;
- The risk of intra-system collisions within a LEO mega-constellation;and
- Known risks with large numbers of expected conjunctions.

Because many of these matters can only be predicted at the application stage, and the problem often cannot be fixed once satellites are launched, Viasat also urges CITEL Administrations to:

- Grant authority in stages (*i.e.*, for parts of the constellation at a time);
- Condition authority appropriately, including conditioning on confirmation that satellites are actually built and operating consistently with the representations in the application; and
- Promptly act to address any material deviations that could pose an increased threat of in-orbit collisions including, but not limited to, withholding authority to serve an Administration while the operator adequately addresses such deviations.

4. <u>**Environmental Issues**</u>

A. <u>*Avoiding Mega-Constellations Polluting Our Air and Contributing to Climate Change*</u>

LEO mega-constellations are designed so their defunct satellites re-enter the atmosphere and vaporize, releasing chemical compounds, including aluminum oxides. This can occur soon after a deployment failure, or after a satellite's useful life ends. Some LEO mega-constellations consist of satellites that have to be constantly replaced after short design (5-year) lives, which would result in a constant stream of satellites vaporizing in the atmosphere---potentially many thousands per year---an exponential increase over what has occurred to date.

The Aerospace Corporation (an advisor to the U.S. Space Force) reports that this massive increase in the number of satellites reentering the atmosphere and releasing chemical compounds could contribute to climate change through, among other things, radiative forcing and ozone depletion.[21] Most of the re-entering mass will vaporize into small particles consisting of what experts call a "zoo of complex chemical types."[22] The stratosphere where this pollution gathers is home to the fragile ozone layer that protects the Earth from ultra-violet (UV) radiation.

We have never before faced a situation where dozens of satellites *each day* would be vaporizing in the atmosphere and releasing harmful chemical compounds into the stratosphere.

It is incumbent on all CITEL Administrations that authorize mega-constellations to serve their jurisdictions to consider these consequences. Every nation has responsibility for actions that facilitate LEO mega-constellation deployment and cause environmental harm.

B. Avoiding Mega-Constellations Polluting Our Dark and Quiet Skies

LEO mega-constellations present a threat to ongoing critical scientific research in fields of optical astronomy and radio astronomy. Questions remain as to how these concerns should be mitigated. These threats exist in the form of three types of interference: satellites in the night sky reflecting sunlight that interferes with optical research telescopes; artificial radio wavelength emissions that interfere with radio telescopes at all times; and the impact on naked eye viewing of the night sky. The growing number of LEO mega-constellation trails in the sky and the disruptive nature of such events is evident in several reports. Furthermore, the aggregate effect of a fully deployed LEO mega-constellation on the visibility of the night sky and on professional astronomical observations has not been adequately considered.

The threats of LEO mega-constellations to critical astronomy-based scientific endeavors recently were addressed by a leading group of experts under the auspices of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), which included representatives of the U.N. Office of Outer Space Affairs, and the International Astronomical Union, among others. Their recent report and recommendation stresses that "[c]utting edge astronomical discoveries can only continue on the basis of an unobscured and undisturbed access to the cosmic electromagnetic signals," and details why mega-constellations are a threat to astronomy.[23] As the report explains, further work to mitigate the adverse

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[21] L. Organski, C. Barber, S. Barkfelt, M. Hobbs, R. Nakagawa, Dr. M. Ross, Dr. W. Ailor, *Environmental Impacts of Satellites from Launch to Deorbit and the Green New Deal for the Space Enterprise*. Aerospace Corporation (December 2020); Debra Werner, *Aerospace Corp. Raises Questions about Pollutants Produced during Satellite and Rocket Reentry.* SpaceNews, December 15, 2020, https://spacenews.com/aerospace-agu-reentry-pollution/.

[22] Martin N. Ross & Leonard David, *An Underappreciated Danger of the New Space Age: Global Air Pollution*, Scientific American, February 2021. https://www.scientificamerican.com/article/an-underappreciated-danger-of-the-new-space-age-global-air-pollution/.

[23] United Nations Office for Outer Space Affairs, International Astronomical Union, IAC, NOIR Lab. *Dark and Quiet Skies for Science and Society: Report and Recommendations*. Online Workshop (December 29, 2020): 12. https://www.iau.org/static/publications/dqskies-book-29-12-20.pdf.

impacts on LEO mega-constellations is urgently needed, and appropriate limits must be adopted and enforced by individual national authorities.[24]

The global community, including CITEL countries, have never before faced a situation where a steady stream of thousands of satellites constantly leaves trails through the sky that disrupt vital scientific research and our enjoyment of the night sky. Viasat urges CITEL Administrations to conduct a full environmental review of the impact of LEO mega-constellations before granting market access and require suitable mitigation to reduce the negative impact on the environment, which may include limits on the number of satellites authorized to provide service.

5. Conclusion

Planning for the future requires that scarce resources, such as near-earth space in LEO, are used wisely. New technological developments and the actions of a few individual companies require rules that ensure equitable access to essential spectrum resources rules and shared access to orbits, a clean atmosphere, and a dark and quiet sky. Taking into account the specific guidance above, Viasat respectfully urges that CITEL Administrations consider a mechanism to allocate LEO satellite counts, orbital trajectories and spectrum fairly among all global nations.

In addition, and prior to granting market access to a LEO satellite mega-constellation to provide service to a CITEL country, Viasat urges CITEL Administrations to require the applicant demonstrate with a suitable showing that its system does not and will not:

- Generate unacceptable levels of interference to GSO satellites;
- Unduly constrain other NGSO satellite operators from providing competitive services;
- Pollute space or impair physical access to space by others who seek to serve CITEL countries;
- Pollute our atmosphere; or
- Pollute the dark and quiet sky, impairing radio and optical astronomy, and astrophotography.

CITEL Administrations can prevent the threats from LEO mega-constellations by thoughtfully evaluating the terms under which these mega-constellations may be allowed to provide service within their borders, and by cooperating with like-minded countries around the world to address these threats. It is extremely important that CITEL Administrations adopt appropriate policies around these issues in order to make sure that they will be able to control their destiny in space through adequate access to spectrum and orbits and preventing any adverse environmental impacts from LEO mega-constellations.

[24] Ibid 15, 34.