Consultation title: Telesat LEO Inc: application for non-geostationary earth station network licence

I. Introduction

Viasat UK Limited (Viasat UK) thanks Ofcom for the opportunity to provide input on the issue of Telesat's applications for NGSO earth station network licences to operate their user terminals in 27.5 – 27.8185 GHz, 28.4545 – 28.8265 GHz and 29.5 – 30 GHz bands (Consultation).[1] In the comments below, Viasat UK urges Ofcom to: (i) conduct an analysis of single-entry and *aggregate* equivalent power flux density (EPFD) emissions by both Telesat's NGSO system and all other NGSO systems serving the UK, (ii) ensure suitable reductions in EPFD levels to protect GSO network operations serving the UK; and (iii) if it moves forward with authorising Telesat's NGSO system, impose suitable conditions, including a requirement that Telesat maintain sufficient angular separation from the geostationary arc to adequately protect GSO networks serving the UK. Viasat UK describes these points in further detail below.

Viasat UK is part of Viasat Inc., a global provider of communication solutions that believes everyone and everything can be connected. The firm's 5,800 employees working out of more than 60 global locations deliver connectivity to consumers, business, governments, and militaries around the world, even in the hardest-to-reach places.

Viasat has decades of experience in both geosynchronous and low-earth orbit (respectively "GEO" and "LEO"): in GEO, the firm currently owns and operates, holds lifetime leases on, or is constructing, a total of 9 satellites, including Ka-Sat. Viasat has also partnered with Avanti to boost Ka-Sat satellite network coverage across Western Europe[2] and more recently signed a long-term Ka band capacity lease agreement with Avanti targeting the energy sector.[3] Viasat has built LEO payloads, designed and manufactured ground networks and user terminals, and/or operated satellites, for the past 30 years.

In the UK, Viasat is teaming up with the Space Industry and contributing to the development of its national space strategy. Viasat UK provides deep security and communications expertise to rapidly deliver new sovereign technologies to the UK's civilian and defence markets - including the Royal Air Force's new F-35 stealth fighter and Royal Navy warships.

Moreover, in March 2021, Viasat opened a State-of-the Art Network Operations Centre & Cyber Security Operations Centre in Aldershot, UK.[4] The facility will support defence government and

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1 *Consultation: Telesat LEO Inc – application for non-geostationary orbit earth station (network) license* (24 June 2022), https://www.ofcom.org.uk/consultations-and-statements/category-3/telesat-network-licence-application.

2 *Viasat Partners Avanti to Boost KA-SAT Satellite Coverage* (7 June 2021), https://www.nasdaq.com/articles/viasat-vsat-partners-avanti-to-boost-ka-sat-satellite-coverage-2021-06-07.

3 Viasat Press Release, *Avanti Communications and Viasat Energy Services sign long term Ka-band capacity lease agreement targeting the energy sector* (23 June 2022), https://investors.viasat.com/news-releases/news-release-details/avanti-communications-and-viasat-energy-services-sign-long-term.

4 Viasat Press Release, *Viasat Opens State-of-the-Art Network Operations Centre & Cyber Security Operations Centre in the UK* (30 March 2021), https://www.viasat.com/about/newsroom/press-releases/viasat-opens-state-art-network-operations-centre cyber-security/.

commercial organisations who rely on the guaranteed resilience of their networks and who are targeted by increasingly sophisticated cyberattacks. The project represents a major investment in the UK, representing more than a £300m investment to support the launch and service roll-out of the impending ViaSat-3 constellation and creating over new jobs.

In March 2022, Viasat and Inmarsat reached agreement on a package of legally binding economic undertakings with the UK Government's Department for Business, Energy and Industrial Strategy.[5] As a result, this cooperation will contribute to create many highly skilled jobs in the UK.

Viasat is also preparing to launch the ViaSat-3 network which is a global constellation of three Ka-band broadband communications satellites in GEO. The first two satellites will focus on the Americas and EMEA. A third satellite will provide service in the Asia-Pacific region, completing global service coverage. The ViaSat-3 constellation is currently in its final construction stage and scheduled for three launches commencing in the second half of 2022, including one that will serve the UK and Europe. The ViaSat-3 satellite network architecture is taking another leap forward in performance, with capabilities of providing cost-effective high-speed broadband to customers featuring speeds of up to 1 Gbit/s and a total throughput above 1 Terabit per second (Tbit/s) per satellite. In addition, each of our next-generation Ultra High Throughput (UHT) ViaSat-4 satellites under development will offer 5-7 times that amount of throughput.

Viasat is one of the world's leading providers of fixed broadband and in-flight connectivity services via satellite, with hundreds of thousands of fixed subscribers across the Americas, Europe, Middle East and North Africa and c.1,500 commercial aircraft in-service. Viasat has pioneered mobile broadband services using innovative antenna designs for Earth stations in motion (ESIM) service to aircraft, ships and other land-based users. These services include connectivity for gate-to-gate for aircraft and port-to-port for maritime, high-speed broadband connectivity for communications and entertainment, cabin support, and fleet digitization for passengers and crew on aircrafts and ships.

As a global industry leader, Viasat has been a strong promoter of responsible and equitable practices designed to ensure that the shared orbital environment remains available for all to use safely. This long-standing commitment is evidenced in Viasat's recent signing of the Paris Peace Forum's 'Net Zero Space' Initiative to tackle the growing space debris crisis. Viasat also stands for a responsible space industry that is committed to fostering public awareness of the risks associated with the proliferation of debris in near-Earth orbits. To this end, company representatives regularly take part in conferences, such as at the 4th edition of the Space Sustainability Summit co-sponsored by the UK Space Agency, which took place in London on 22 and 23 June.

We trust our suggestions below, in our responses to the questions raised in the Consultation, will help Ofcom ensure that any spectrum authorisations it chooses to award create a fair and level playing field for all actors, whether in GEO, LEO, or non-geostationary orbits (NGSO) other than LEO, and do not pose a threat to efficient spectrum use and the UK's national interests.

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5 Viasat Press Release, *Viasat and Inmarsat reach agreement with UK government on a plan to increase highly-skilled jobs and R&D investment in UK Space sector* (21 March 2022), https://www.viasat.com/about/newsroom/press-releases/viasat-inmarsat-reach-agreement-uk-government-plan-increase/.

II. Viasat response to the consultation questions

Question 1: Do you anticipate this satellite network will pose coexistence challenges to existing services?

Question 2: Are the measures set out by the applicant to enable coexistence with future systems reasonable?

Question 3: Do you believe this application would benefit or harm future competition between NGSO services in the UK? Please provide details.

Question 4: Do you have any additional concerns or comments regarding this application?

A. Ofcom must protect GSO network services serving the UK.

In its recent space spectrum strategy consultation publication[6], Ofcom recognised that:

1) "*GSO satellites currently deliver significant benefits, including (but far from limited to) the provision of satellite TV to UK users"*;
2) *"according to the Radio Regulations, in most bands NGSO systems shall not cause unacceptable interference to, or claim protection from, GSO networks"*; and
3) *"interference to GSO satellites can occur from a single NGSO system or from aggregate impact of multiple NGSO satellites, and the existing international rules require that in most bands NGSO systems shall not cause unacceptable interference or claim protection from GSO networks"*.

The movements of NGSO satellites across the sky create opportunities for time varying interference into GSO networks. Unless an NGSO operator, like Telesat, employs appropriate mitigation measures, in-line interference events with GSO networks will repeatedly degrade and disrupt services to end users of GSO networks.

Today's 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 advancements in technology, modern GSO satellites are capable of providing more than 1 Tbit/s of total capacity each, with even higher amounts of throughput expected in the next few years.

GSO networks achieve this unprecedented increase in capacity due in part to increased spectral efficiency which is facilitated by employing satellite receivers with low noise temperatures and high antenna gains (G/T). Today, even a single NGSO system, like Telesat, has the potential to cause interference into GSO networks. Multiple NGSO systems operating simultaneously on the same frequencies pose an even greater aggregate interference risk to those GSO networks.

Managing NGSO interference into GSO networks is critical to ensure the continuing availability and reliability of vital GSO services in the UK. Ofcom must protect these advanced GSO ultra-high

6 Ofcom consultation on Space Spectrum Strategy, No. 6.43 (15 March 2022), https://www.ofcom.org.uk/__data/assets/pdf_file/0024/233853/consultation-space-spectrum-refresh.pdf.

throughput (UHT) networks to ensure continued availability, innovation and competition. Both GSO network and NGSO system operators need regulatory certainty for interference-free sharing of spectrum, including national spectrum access, to plan their operations and services for end users.

B. Ofcom must ensure Telesat maintains adequate angular separation from the GSO arc.

Unless Telesat's communication links are angularly separated from the GSO arc by a sufficient amount, they could easily degrade service levels and cause capacity losses to the GSO networks with which Telesat seeks to compete, including those that serve the UK and Europe. Angular separation is a relatively simple operational technique where the NGSO satellites avoid operating within a suitable angular separation around the GSO arc. If using one particular NGSO satellite to serve a given location would not maintain sufficient angular separation, then a different satellite would be used, and the other NGSO satellite would be used to serve a different location where it would be able to maintain the required angular separation. This concept is depicted in Figure 1.

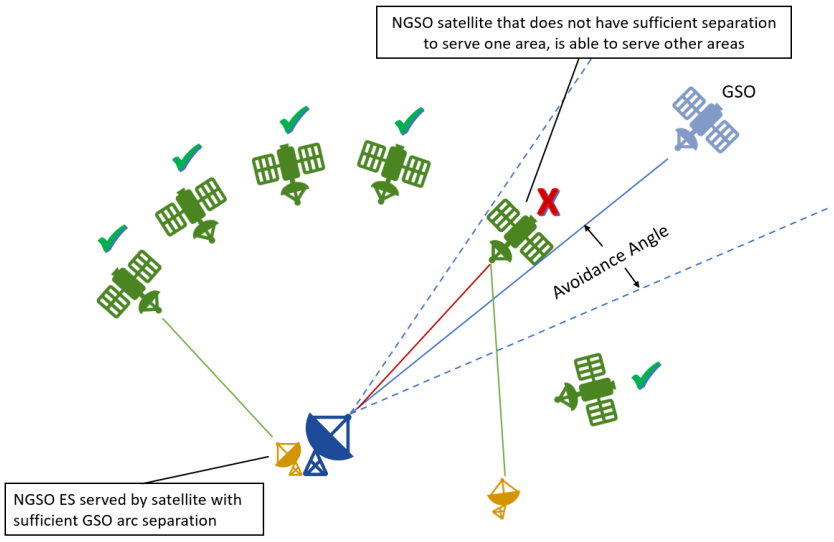

Figure 1 – NGSO System Employing GSO Avoidance Angle.

Notably, angular separation imposes virtually no constraint on NGSO system capacity as NGSO systems like Telesat have multiple options for assigning different satellites to serve different locations on the Earth. And they regularly hand off traffic from one NGSO satellite to another as the satellites move rapidly across the sky. Angular separation is routinely used by NGSO systems in ITU coordination agreements to protect GSO networks.

Although GSO arc avoidance has the potential to effectively mitigate some potential interference from NGSO systems into GSO operations, the effectiveness of this technique depends entirely on the avoidance angle that is specified. The sufficiency of that angle can be evaluated only in light of information about the radiofrequency design and EPFD performance of the relevant NGSO system.

This underscores the need to define appropriate up-front parameters that are shown through mathematical calculation to be reasonably likely to mitigate the potential for interference from Telesat into GSO network operations—*e.g.,* by specifying a precise and appropriate GSO arc avoidance angle on an *ex-ante* basis.

For these reasons, and since, in the present case, the demonstration of the existence of adequate measures to avoid harmful interference should be provided *before* granting any authorisation (see below), Ofcom should not adopt its preliminary views subject to this public consultation.

If Ofcom were nonetheless to consider granting Telesat a spectrum authorisation, it should, at a minimum: (i) calculate the minimum GSO arc avoidance angle that would ensure that the Telesat NGSO system protects from interference GSO networks serving the UK and Europe; (ii) allow interested parties to evaluate the efficacy of the proposed value; and (iii) require Telesat to maintain a suitable GSO arc avoidance angle as a condition of any authorisation that ultimately may be granted in this proceeding.

To assist in that analysis, in addition to the information already provided by Telesat, Ofcom should require Telesat to also provide the following information:

- Number of total beams on each satellite serving UK and Europe;
- Number of co-frequency beams on each such satellite;
- Number and size of frequency channels on each such satellite; and
- How Telesat avoids interference to GSO networks created by earth station and satellite sidelobes, and earth station backlobes, particularly when phased array antennas are employed.

This information is relevant to assessing Telesat's potential interference impact on GSO networks, the potential for spectrum sharing with other NGSO systems discussed below, and thus Telesat's impact more broadly on the spectrum and competitive environments in the UK and Europe.

In order to ensure that the bases on which Ofcom ultimately grants an authorisation (should it decide to do so) do not change by virtue of continuing iterations of the Telesat NGSO design, Ofcom should also (i) specify that Telesat not modify the radiofrequency characteristics of its satellite system without prior consent from Ofcom, and (ii) require that Telesat provide a bi-annual report on iterations of its NGSO design to ensure compliance with that condition.

C. Ofcom must ensure that Telesat's NGSO system does not exceed single-entry and aggregate EPFD limits when serving the UK.

Most portions of the frequency bands 27.5 – 27.8185 GHz, 28.4545 – 28.8265 GHz and 29.4625 – 30 GHz, which Telesat intends to use for its NGSO system operations in the UK, are subject to single-entry limits on the uplink equivalent power flux density (EPFD) levels it may generate toward GSO satellites.[7] The corresponding downlink frequency bands 17.8-18.6 GHz and 19.7-20.2 GHz[8] are subject to both single-entry and aggregate EPFD limits for protection of GSO earth stations[9].

"Single-entry" EPFD limits constrain the amount of interference that the Telesat system itself may generate with respect to GSO networks. "Aggregate" EPFD limits constrain the amount of interference

7 ITU Rad. Reg. Art. 22.

8 "TELSAT-NET-1 Annex", Annex 1 of Telesat UK earth station network license application.

9 ITU Rad. Reg. Art. 22; ITU Res. 76.

that *all* NGSO systems (including Telesat) may generate in total, on a cumulative basis. These aggregate limits must be shared and apportioned among all NGSO systems using the overlapping frequencies. Both "single-entry" and "aggregate" EPFD limits are specified as a series of different EPFD levels that are permitted for time-varying intervals. One EPFD limit must be satisfied 100 percent of the time; and other EPFD limits must be satisfied for other, varying percentages of time.[10]

Notably, the ITU's methodology and implementing software for assessing expected EPFD levels from NGSO operations rely on an algorithm that derives a "worst-case geometry" found at one particular location on the Earth's surface.[11] That is, the algorithm attempts to identify, for the specific NGSO satellites under the relevant filing and a representative GSO network, the single location that results in the highest single-entry NGSO EPFD level that can be expected. Again, this value is produced for a very short period of time, and thus lies at the bottom of the relevant EPFD results curve (*i.e.*, the alignment of the NGSO system with the GSO network that produces the highest instantaneous interference level---for a very small percentage of the time). Critically, EPFD level distributions predicted at locations other than the one identified by the algorithm can exceed the relevant EPFD limit curve even though the peak predicted EPFD at that location is lower than that at the so-called "worst-case" location.

For this reason, an ITU evaluation would not be expected to reveal the exceedances of EPFD limits in the UK. Therefore, Ofcom must perform this compliance analysis now to ensure that the Telesat NGSO system meets the ITU Radio Regulations (RR) Article 22 EPFD limits *in the UK,* both individually, and in the aggregate considering all other co-frequency NGSO serving the UK, including those discussed below.

The single entry NGSO system EPFD limits in ITU RR Article 22 were derived assuming that a maximum of 3.5 NGSO systems would operate simultaneously in the same or overlapping frequencies. Yet Ofcom now faces the possibility of 5 NGSO systems operating serving the UK. The Consultation states that currently OneWeb, Kepler and SpaceX hold earth station network licenses to operate NGSO user terminals in the UK. As noted by Ofcom in No. 1.6 of the Consultation, "*these operators intend to deploy terminals in Ku band*". However, the Ofcom license permits them to use Ka band as well. Additionally, SpaceX holds Ka band gateway earth station licenses at three locations in the UK and has applied for Ka band gateway licenses at six more locations within the UK.[12] Moreover, Ofcom, in its Space Spectrum Strategy consultation[13], also identified Amazon's Kuiper NGSO system as another commercial NGSO system intending to operate in Ka band.

For these reasons, Viasat submits that Ofcom must (i) consider the aggregate EPFD impacts of these various NGSO systems before allowing them to serve the UK, (ii) determine the permitted level of

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10 See Rad. Reg. Art. 22.

11 *See generally* ITU-R Rec. S.1503.

12 https://www.ofcom.org.uk/__data/assets/pdf_file/0017/239003/consultation-starlink-ngso-application.pdf.

13 https://www.ofcom.org.uk/__data/assets/pdf_file/0024/233853/consultation-space-spectrum-refresh.pdf.

interference impact on GSO networks serving the UK, and (iii) apportion the maximum permitted level of impact among the various NGSO systems it allows to serve the UK.

In the downlink bands, 17.8-18.6 GHz and 19.7-20.2 GHz, that Telesat intends to use, ITU Radio Regulations Res. 76[14] explicitly addresses apportioning this EPFD impact among different NGSO systems:

1. administrations operating or planning to operate non-GSO [NGSO] FSS systems … shall take all possible steps, including, if necessary, by means of appropriate modifications to their systems, to ensure that the aggregate interference into GSO FSS and GSO BSS networks caused by such systems operating co-frequency in these frequency bands does not cause the aggregate power levels given in Tables 1A to 1D to be exceeded (see No. 22.5K);

2. in the event that the aggregate interference levels in Tables 1A to 1D are exceeded, administrations operating non-GSO FSS systems in these frequency bands shall take all necessary measures expeditiously to reduce the aggregate EPFD levels to those given in Tables 1A to 1D, or to higher levels where those levels are acceptable to the affected GSO administration (see No. 22.5K).

Viasat has demonstrated in its response for Ofcom's consultation on Starlink's gateway license application[15] that the proposed **Starlink system *alone* would consume the entire aggregate downlink EPFD "budget"**, in both Ku and Ka band. Telesat's NGSO system has the potential to worsen the aggregate EPFD exceedances created by the Starlink system, causing far more interference into GSO networks than is permitted by ITU Radio Regulations under the Res. 76 aggregate EPFD limits.

Additionally, unless Ofcom intervenes to take appropriate actions before authorising these two NGSO systems, the aggregate EPFD levels generated by these two systems in the UK, which would consume (and in fact exceed) all of the aggregate EPFD "budget", will foreclose opportunities for other parties to operate their own NGSO systems in the UK, **harming competition**.

The aggregate EPFD 'budget' must be equitably apportioned among all NGSO systems using the same or overlapping frequencies. Notably, the ITU neither checks compliance of NGSO systems with ITU Res. 76 aggregate EPFD limits nor has any means by which it can enforce reduction of aggregate EPFD levels if the limits are exceeded. That responsibility falls on individual administrations and regulators, such as Ofcom, that consider authorizing NGSO system operations to provide service in their countries.

Aggregate NGSO system uplink (Earth-to-space) EPFD limits are not specified in the Radio Regulations. However, Figure 2 below shows that an increasing number of NGSO system uplinks can significantly

14 ITU-R, Radio Regulations, Resolution 76, "Protection of geostationary fixed-satellite service and geostationary broadcasting-satellite service networks from the maximum aggregate equivalent power flux-density produced by multiple non-geostationary fixed-satellite service systems in frequency bands where equivalent power flux-density limits have been adopted."

15 *See* Annex A in Viasat comments on Ofcom consultation regarding Starlink six gateway license application (submitted on 19th July 2022).

degrade the service provided by advanced GSO satellites with highly efficient satellite receivers in space (high G/T).[16]

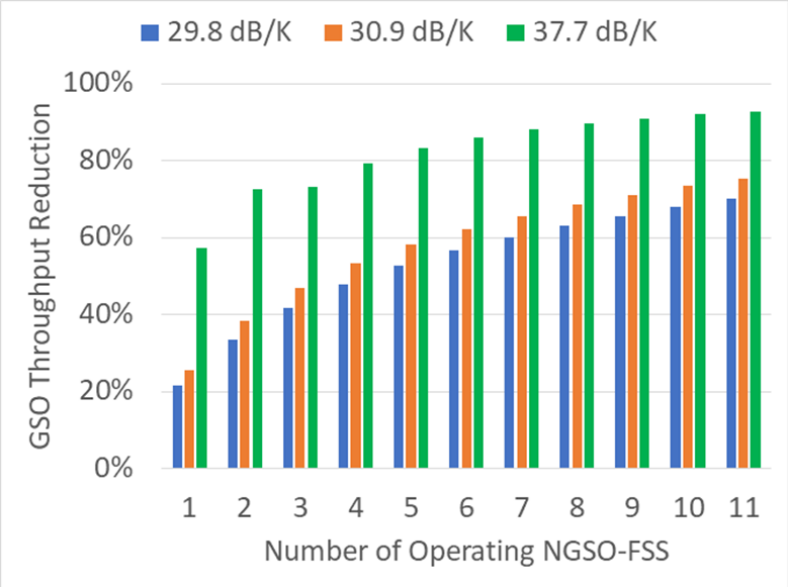

Figure 2 – Ka band GSO throughput reduction with current EPFD up limit.

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

For assessing aggregate uplink NGSO interference into GSO satellites, Viasat recommends that Ofcom apply an appropriate aggregate interference threshold (e.g., ITU-R S.1323)[18] with respect to all NGSO systems that serve the UK.

In light of Telesat's application for a Ka earth station network license, it is critical that Ofcom perform an independent assessment to determine the *aggregate* EPFD levels generated, towards GSO networks, from *all* co-frequency NGSO systems that are already licensed to operate in the UK and the NGSO systems that are seeking licenses to operate in the UK.

16 Based on each NGSO system operating at the EPFD limit of -162 dBW/m2/40 KHz per ITU Rad. Reg Table 22-2.

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

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

It would be practically impossible in the future to directly measure the EPFD levels generated into GSO networks by separate NGSO systems. Among other things, EPFD statistics include a percentage-of-time element, such that EPFD levels would need to be measured over and against time and then processed to check against the EPFD limits—a process that is computationally intensive and time-consuming for the same reasons that any up-front EPFD analysis is time-consuming. In addition, where multiple NGSO systems operate in the same band, it is not practical to differentiate between the contributions of each NGSO system given all the main-beam and sidelobe transmissions of numerous satellites of those multiple NGSO systems. The way in which different NGSO systems contribute to the overall EPFD level received by a GSO earth station is illustrated by Figure 3, below. From the perspective of the GSO earth station, EPFD interference is EPFD interference — *i.e.,* the GSO earth station cannot isolate individual components of that interference or trace those components to their specific sources. This is why it is critical for Ofcom to evaluate Telesat's EPFD compliance (including the contributions of Telesat earth stations operating in the UK) before granting an authorisation for Telesat service in the UK.

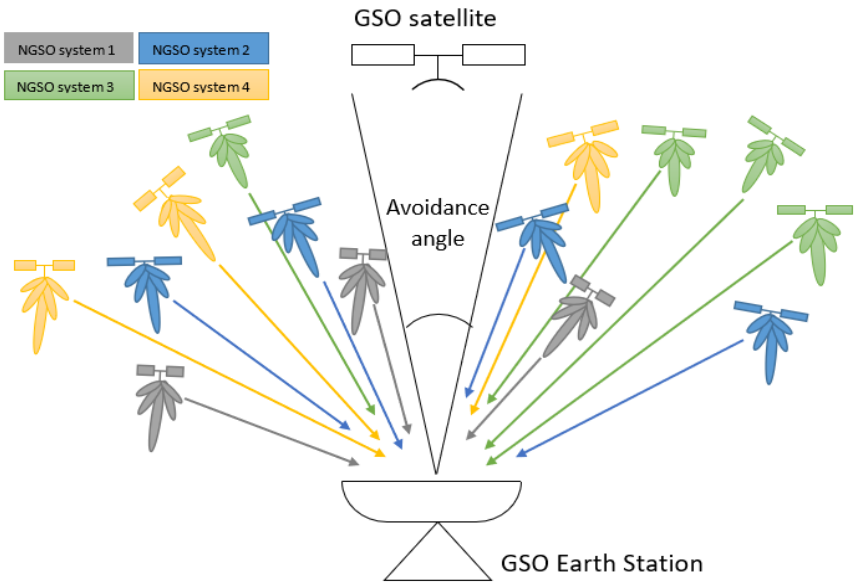

Figure 3 – Aggregate Mainlobe and Sidelobe Interference Contributions from Multiple NGSO Systems into GSO Earth Station.

Additionally, Ofcom should develop an effective mechanism by which it can determine the amount of reduction in transmissions across multiple NGSO systems in order to meet the aggregate EPFD limits and require NGSO operators serving the UK to implement such a reduction in transmission power to prevent aggregate interference to other satellite systems and networks also serving the UK.

III. Conclusion

For these reasons, Ofcom should:

- Conduct its own analysis to ensure that Telesat complies with *all* single-entry EPFD limits in the UK;

- Conduct its own analysis of the aggregate EPFD levels from all NGSO systems seeking to serve the UK to ensure that the aggregate EPFD levels do not exceed any of the EPFD limits in the UK;
- For assessing aggregate uplink NGSO interference into GSO satellites, apply an appropriate aggregate interference threshold (e.g., ITU-R S.1323) with respect to all NGSO systems that serve the UK; and
- Develop a mechanism by which it can ensure that the aggregate EPFD "budget" and the burden to resolve aggregate interference is apportioned equitably amongst all NGSO systems that serve the UK.

Should Ofcom decide, after its assessment, to grant Telesat the requested authorisations to use radio spectrum, Ofcom should in any case subject such authorisations to the following conditions:

- Ensure non-interference into and mitigation of other adverse impacts on GSOs, including by requiring:
  - The Telesat NGSO system to maintain a suitable GSO arc avoidance angle when serving the UK;
  - Telesat not to cause unacceptable interference into GSO networks and not to claim interference protection from GSO networks;
  - Telesat to have an operational feature that allows it to immediately interrupt radio frequency emissions to ensure satisfaction of this non-interference requirement, and to cease emissions upon notice of unacceptable interference;
  - If interference into a GSO network occurs, Telesat to cease operations and not recommence operations until it addresses the cause of such interference by, among other things, increasing angular separation, reducing power, shaping antenna beams differently; and
  - 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, that Telesat cooperate with the operators of such other NGSO systems, taking the technical measures necessary to eliminate the interference.

- Require that Telesat not modify the characteristics of its LEO system without filing a modification application with Ofcom that Ofcom approves (in order to maintain its authorisations in the UK).

- Require that Telesat provide, every 6 months, a report showing compliance with the obligations attached to the authorisations granted.

Finally, Viasat firmly believes that these types of conditions could be equitably applied to all LEO constellations that seek to serve the UK. Plans exist for hundreds of thousands of LEO satellites from multiple large constellations and equitable conditions are essential for effective competition in the marketplace. The conditions should consider that to the extent LEO constellations are economically viable, there are likely to be many – not just a few.