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LATHAM & WATKINS LLP

August 29, 2018

VIA ELECTRONIC FILING

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Viasat, Inc., *Ex Parte* Submission Responding to Iridium, IB Docket No. 17-95

Dear Ms. Dortch:

Viasat responds to *ex parte* submissions by Iridium that reiterate its same call to prevent ESIMs from sharing the 29.25-29.3 GHz band segment with Iridium's NGSO MSS feeder link station operations.[1]

Viasat and Inmarsat have demonstrated through detailed and unrebutted technical analyses that ESIMs can operate at 29.25-29.3 GHz without any harm to Iridium's feeder link operations. Allowing ESIM access to this spectrum would facilitate the provision of WiFi and other critical communications services to aircraft, marine vessels and vehicles. In contrast, Iridium's approach would continue the severe underutilization of a valuable spectrum resource across wide swaths of the United States.

Notably, Iridium has not put any technical analysis on the record to support its opposition to sharing. For instance, while Iridium claims that the long-term interference threshold that Viasat uses in its analysis is not appropriate, Iridium has not indicated what the appropriate protection criteria should be. Instead, Iridium simply proposes to exclude ESIM access from 29.25-29.3 GHz entirely without further justification. Iridium's rejection of Viasat's analysis

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[1] *See* Iridium Communications, Inc., *Ex Parte* Filings: *Ex Parte* Letter, IB Docket No. 17-95 (filed June 11, 2018) ("Iridium June 11 *Ex Parte*"); Notice of *Ex Parte* Presentation, Office of Chairman Pai, IB Docket No. 17-95 (filed June 15, 2018) ("Iridium June 15 *Ex Parte*"); Notice of *Ex Parte* Presentation, Office of Engineering and Technology, IB Docket No. 17-95 (filed June 18, 2018) ("Iridium June 18 *Ex Parte*"); Notice of *Ex Parte* Presentation, Office of Commissioner O'Rielly, IB Docket No. 17-95 (filed June 28, 2018) ("Iridium June 28 *Ex Parte*"); *Ex Parte* Submission, IB Docket No. 17-95 (filed July 11, 2018); ("Iridium July 11 *Ex Parte*").

does not withstand scrutiny. In this submission, Viasat supplements its prior analysis demonstrating compatibility with Iridium in the attached Technical Statement.

As a threshold matter, the 29.25-29.5 GHz band segment is clearly underutilized, when simply considering the Commission's original intent for the uses of this spectrum. When the Commission originally adopted a designation for MSS feeder link operations at 29.25-29.5 GHz in 1996 on a shared basis with the FSS, it contemplated that at least three MSS systems would operate in this band segment.[2] Only Iridium's system was brought to fruition, and only using 50 megahertz of this spectrum. And in order to ensure intensive use of this segment of the Ka band, the Commission allowed GSO FSS VSAT operations on a co-primary basis.[3] Because ESIMs operate within the same envelope as VSATs, there is no reason why ESIMs should not also be allowed to share with Iridium's MSS feeder links.

I. ALLOWING ESIMS USE OF THE 29.25-29.3 GHZ BAND SEGMENT ENABLES EFFICIENT SPECTRUM USAGE AND IS NECESSARY TO MEET THE NEEDS OF CONSUMERS

A recent study by the London School of Economics predicts exponential growth of WiFi service to airplanes in the coming decade, thus further confirming the need for access to spectrum for ESIMs to respond to this market demand: "By 2035, it is likely that inflight connectivity will be ubiquitous across the world."[4] Indeed, Viasat is currently connecting approximately 46 million personal devices per year on airplanes.

Moreover, the vast majority of Viasat's current broadband capacity (*i.e.*, the portion of the Ka band it currently uses) is used to provide broadband service to customers in their homes. The vast majority of Viasat's potential Ka band spectral capacity simply is not available to provide in-flight connectivity. Thus, Iridium's claim that Viasat does not need access to the

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[2] *Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Systems*, First Report and Order, 11 FCC Rcd 19005 ¶ 63 (1996).

[3] *See Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.7 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite-Service Use*, Second Order on Reconsideration, 17 FCC Rcd 24248 ¶ 24 (2002); *see also* 47 C.F.R. § 25.258.

[4] Dr. Alexander Grous, London School of Economics and Political Science, Sky High Economics, "Chapter One: Quantifying the commercial opportunities of passenger connectivity for the global airline industry" at 3, *available at* http://www.lse.ac.uk/business-and-consultancy/consulting/assets/documents/sky-high-economics-chapter-one.pdf.

29.25-29.3 GHz band, and Iridium's fanciful assertions of the number of airline customers that could be supported in the rest of the Ka band,[5] have no basis in reality.

As Viasat has explained, allowing ESIMs to share the 50 megahertz of spectrum at 29.25-29.3 GHz with Iridium's feeder link operations, fulfilling the Commission's intentions for the band, would facilitate efficient spectrum usage by enabling the use of channel carriers of varying sizes throughout the entire 29.25-30.0 GHz range on GSO spacecraft. Viasat has put into the record a detailed analysis illustrating the fragmentation inefficiencies, and the reduction in flexibility to manage spectrum use by the GSO network overall, that would result if ESIMs were denied access to this 50 megahertz, because of the resulting need to use smaller bandwidth carriers.[6] Because ESIMs operate within the same networks as traditional VSAT terminals, both types of earth stations can use the same channels and carriers if the spectrum is aligned. As Viasat previously illustrated, the amount of capacity enabled by access to the 29.25-29.3 GHz band segment, when multiplied by the beams on several high-throughput satellite systems with U.S. coverage, would be sufficient to serve the equivalent of 250,000 streaming video customers at currently provisioned rates.[7]

This uplink capacity is critical for the provision of video streaming, because this "return link" (from the aircraft to the satellite) provides the acknowledgement that streaming data is being received and thus supports the required and continued signal processing that underlies the streaming service. Thus, Iridium is wrong that streaming video does not consume uplink capacity.[8] Streaming video is just an illustrative example of the additional uses to which the 29.25-3 GHz band segment could be put. Other examples include cockpit communications and the transmission of valuable flight information to airline operational facilities.

Therefore, Iridium's claim that access to the 29.25-29.3 GHz for ESIMs is "insignificant" is simply a mischaracterization of fact.[9] Instead of addressing Viasat's analysis and the resulting tangible efficiency increases, Iridium's rebuttal consists only of a semantic argument disputing whether excluding 29.25-29.3 GHz from the spectrum available for ESIMs is appropriately analogized to a "donut hole." Regardless of whether the 50 megahertz segment is in the middle or at the edge of a band segment, the fact remains that excluding this spectrum from ESIM use, when other VSATs already have access to this spectrum, creates an unnecessary void that results in measurable inefficiencies.

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[5] *See, e.g.,* Iridium June 18 *Ex Parte* at 3.

[6] *See* Viasat, Inc., *Ex Parte* Response to Iridium, IB Docket No. 17-95 (filed Apr. 26, 2018) ("Viasat April 26 *Ex Parte*").

[7] *See id.* at 2.

[8] *See* Iridium June 11 *Ex Parte* at 2.

[9] *See, e.g.,* Iridium June 28 *Ex Parte* at 2.

II. IRIDIUM'S CLAIMS ARE INCONGRUOUS WITH REALISTIC OPERATING CONDITIONS AND UNSUPPORTED BY ANY TECHNICAL ANALYSIS

Iridium resists sharing the 29.25-29.3 GHz band segment with ESIMs in the face of the uncontested compatibility showings on the record. That is, Iridium's claim that ESIMs will create interference to Iridium's feeder uplinks,[10] is not supported by any technical analysis. Rather, Iridium's most recent *ex parte* submission repeats the unsubstantiated claims that it is somehow "impossible" for Iridium to share spectrum with aeronautical ESIMs, and that the altitude of the plane somehow makes the interference analysis "prohibitively complex."[11] As explained in detail in the attached Technical Statement, there is no appreciable difference between an earth station on the ground and one operating on an airplane flying at 35,000 feet when calculating the distances toward an Iridium satellite that is hundreds of kilometers away.

And while Iridium claims that scenarios could arise in which ESIMs exceed Iridium's alleged protection criteria, Iridium never specifies what those criteria are.[12] Indeed, Iridium utterly fails to put forth any quantitative analysis to demonstrate what the impact to its system might be. Nonetheless, Viasat conducted an analysis utilizing the long-term and short-term criteria proposed in the ITU process. Viasat's analysis illustrates the impact of multiple aeronautical ESIMs operating on multiple GSO satellite networks in the vicinity of Iridium's gateway (included as Exhibit 1 to the Technical Statement) and confirms that the aggregate impact of ESIMs in a realistic operating scenario would not harm Iridium's operations. Therefore, Iridium's claims that the aggregate impact of ESIMs would present an "exceptional risk" of interference are unavailing.[13] In any event, any aggregate impact to Iridium's satellite receivers could be monitored and resolved in the future, in the same manner the Commission committed to address aggregate interference from UMFU stations into FSS satellite receivers at 28 GHz,[14] or the aggregate interference from multiple NGSOs into GSO spacecraft.[15]

As explained above, the increased capacity facilitated by making the additional 50 megahertz available for ESIMs would be made possible by the efficiencies gained through reuse of the spectrum on multiple satellite beams (as is required by the Commission's rules[16]) and the ability of multiple satellite systems (not just Viasat's) to use the spectrum across the U.S. In other words, the additional capacity that could be supported by allowing ESIMs to share 29.25-

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[10] *See id.* at 1.

[11] *See* Iridium July 11 *Ex Parte* at 2-3.

[12] *See id.* at 3-4.

[13] *See id.* at 3.

[14] *See Use of Spectrum Bands Above 24 GHz for Mobile Radio Services*, Report and Order, 31 FCC Rcd 8014 ¶ 69 (2016).

[15] *See Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, Report and Order, 32 FCC Rcd 7809 ¶ 35 (2017).

[16] 47 C.F.R. § 25.210(f).

29.3 GHz illustrates the vast potential across the U.S. that would be gained by allowing ESIM access in this 50 megahertz segment.

* * * * *

Therefore, Viasat urges the Commission to allow ESIM operations to share the 29.25-29.3 GHz band segment with Iridium's feeder link operations.

Respectfully submitted,

/s/

John P. Janka
Elizabeth R. Park

Attachment

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TECHNICAL STATEMENT

Additional Technical Analysis Regarding Sharing with Iridium MSS Feeder Links at 29.25-29.3 GHz

ESIMs Can Operate Successfully on Multiple GSO Networks While Also Protecting Iridium

Contrary to what Iridium suggests, the operation of ESIMs on multiple GSO networks does not make it impossible for Iridium to share spectrum.

In Annex B of the USWP4A ITU-R contribution R15-WP4A-C-0675!N13!MSW-E.doc, Viasat analyzes the impact of multiple aero ESIMs operating on multiple GSO satellite networks while flying near the Iridium gateway.[1] A copy of that analysis is attached as Exhibit 1.

That analysis considers the aggregate impact of operations from four different GSO satellites with six simultaneously operating ESIMs per satellite, each flying routes that pass over or near the Iridium gateway. Figure 2 in Annex B of the analysis demonstrates that the long-term interference criteria for Iridium is never exceeded, and in fact is met with considerable margin. While there are no published short-term criteria for the Iridium system, the draft ITU Report does include an example aggregate short-term criteria of -3 dB I/N with time not to be exceeded of 0.01% of the time. The analysis demonstrates that this criterion is also met with margin, even with no isolation zone around the Iridium gateway.

In fact, the odds of there being a direct in-line event between an ESIM and the Iridium system are very low—in the range of a few times a month—because of the near perfect geometrical alignment that must occur between the moving ESIM and the moving Iridium satellite. Then, when one factors in the duty cycle of an ESIM, the likelihood that an ESIM is actually transmitting during an in-line event are even lower—about 100 times lower based on the typical 1% duty cycle of Viasat's current ESIM technology. Nevertheless, while no published Iridium short-term criteria exist, Viasat's analysis shows that any reasonable short-term criterion could be satisfied even when accounting for the aggregate ESIM traffic of multiple GSO networks.

The Altitude of an Airplane Does Not Make Sharing Prohibitively Complex

The maximum altitude of an aircraft is in the range of 1% of the distance to the satellites at issue and does not make an appreciable difference to the operating environment as compared to an earth station located on the ground. Iridium's claims that ESIMs operating at altitude create an additional and potentially unresolvable layer of complexity are not supported by any analysis of the geometries and the relevant technical values involved, but rather merely a grossly out of scale figure depicting an ESIM flying over a MSS feeder link gateway.[2] A brief review of the facts shows the failings in Iridium's claim.

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[1] ITU-R document R15-WP4A-C-0675!N13!MSW-E.doc

[2] *See* Iridium July 11 *Ex Parte* at Attachment.

At nadir, an aircraft flying at 35,000 ft is only about 1.4% of the distance between the gateway and the Iridium satellite, rather than about 1/3 the distance between the gateway and the Iridium satellite as depicted in the Iridium figure. At nadir, the free space path loss between the Iridium gateway and their satellite is about 179.6 dB, and for an aircraft at 35,000 ft above the gateway is about 179.5 dB.

At the minimum operational elevation angles of 5 degrees where the slant range is about 2725 km, the path loss between gateway and satellite is about 192.5 dB. An ESIM operating a few hundred km away from the Iridium gateway but within view of the receiving beam of the Iridium satellite would have a path loss of about 191.1 dB. The difference in actual distances between the gateway and Iridium satellite and an ESIM and Iridium satellite again are within a few percent of each other, not 1/3 of the distance as Iridium has depicted.

At this low elevation angle, even when the ESIM is in view of the main beam of the Iridium feeder link receiving beam, the path loss is about 11.5 dB greater than at nadir. Further, the operating elevation angles required to communicate between the ESIM and the target GSO satellite are significantly greater than 5 degrees, so any energy emitted from an ESIM sidelobe towards the Iridium satellite will be reduced by 40 dB or more in EIRP density from the on-axis value.

The greater path loss and off-axis gain reduction at the low elevation angles reduce the potential energy toward the Iridium satellite by more than 51.5 dB from the worst-case nadir values. This, coupled with the relatively insensitive receiving beam G/T of the Iridium satellite, make it impossible for an ESIM to interfere at the low elevation angles. Thus, there is simply no technical basis for the huge isolation zone radiuses Iridium claims are required due to the claimed unresolvable geometric complexity caused by factoring in the altitude of an ESIM.

The Duty Cycles Employed in Viasat's Network Facilitate Coexistence with Iridium's Operations

While it provides no technical analysis, Iridium surmises that sharing the 29.25-29.3 GHz band segment with ESIMs must cause interference to Iridium's feeder link stations because the ESIMs might operate at duty cycles that are higher than the typical level cited for Viasat's TDMA networks.[3] While Iridium is free to imagine any number of fanciful scenarios, in fact actual duty cycles used by TDMA network operators per terminal are fairly low and trending lower as symbol rates increase.

In a TDMA network, only one user transmits at any given time, thus there is only ever one simultaneous user per beam. Viasat operates multiple generations of TDMA terminals. Older terminals compatible with ViaSat-1 and WildBlue-1 operate at lower symbol rates and require somewhat higher duty cycles. Newer generation terminals compatible with ViaSat-2

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[3] *See* Iridium June 11 *Ex Parte* at 2.

operate at significantly higher symbol rates and accordingly operate using lower duty cycles – typically less than 1% for aero ESIMs.

Because only one earth station in a satellite beam can utilize a frequency at any given time in a TDMA network, in a network in which individual earth stations operate at a low duty cycle, each terminal is only transmitting on a frequency for a very small percentage of the time, and thus significantly reducing the potential for interference while at the same time allowing a greater number of users to access the network. In contrast, an earth station operating at a high duty cycle is transmitting for a longer period and affording fewer opportunities for other stations to transmit (*e.g.*, an earth station operating at a 100 percent duty cycle is transmitting consistently on all of the spectrum).

Finally, as discussed above, Iridium provides no detailed analysis backing up its claims of the potential for interference. In considering the potential for interference to the feeder link, discussions have historically focused on I/N with little consideration to C/I. Iridium's gateway license allows for a very high EIRP. When examining the authorized transmit power for the Iridium gateway and assuming typical fade margins used on non-adaptive coding and modulation links in the Ka band, significant margin is typically present during clear sky conditions. Should an inline event, however unlikely, occur during clear sky conditions, the potential for unacceptable interference to result is further minimized due to the unused link margin which has not been consumed by atmospheric losses. As a result, even were the I/N criteria briefly not met it is very likely that the resulting C/(N+I) would still be acceptable.

Exhibit 1

ITU-R Working Document Towards a Preliminary Draft New Report ITU-R S.[ESIM]

R15-WP4A-C-0675!N13!MSW-E

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Subject: WRC-19 agenda item 1.5 Resolution **158 (WRC-15)**	**6 March 2018**
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Annex 13 to Working Party 4A Chairman's Report

WORKING DOCUMENT TOWARDS A PRELIMINARY
DRAFT NEW REPORT ITU-R S.[ESIM]

Earth stations in motion (ESIM) compatibility with non-GSO MSS feeder links in the bands 19.3-19.7 GHz and 29.1-29.5 GHz

[Editor's note: This document is a compilation of contributions received on this subject at the February/March 2018 meeting of WP 4A and its content is not agreed at this time]

[Editor's note: Align appropriately the language used in this document with the draft CPM text.]

[Editor's note: This report should have guiding measures to facilitate Administrations in the implementation of the Resolution attached to the draft CPM text.]

1 Introduction

WRC-15 adopted agenda item 1.5 for WRC-19, to consider the use of the frequency bands 17.7-19.7 GHz (space-to-Earth) and 27.5-29.5 GHz (Earth-to-space) by earth stations in motion (ESIM) communicating with geostationary space stations in the fixed-satellite service (FSS) and take appropriate action.

2 Background

ITU-R adopted Reports ITU-R S.2223 and ITU-R S.2357 on earth stations on mobile platforms (ESOMPS). Report ITU-R S.2223 covers the technical and operational requirements for GSO FSS ESOMPs in bands from 17.3 to 30.0 GHz, whereas Report ITU-R S.2357 covers the technical and operational guidelines for ESOMPs communicating with geostationary space stations in the FSS in the frequency bands 19.7-20.2 GHz and 29.5-30.0 GHz.

WRC-15 adopted footnote RR No. **5.527A** for the bands 19.7-20.2 GHz and 29.5-30.0 GHz, which states that earth stations in motion can communicate with GSO FSS space stations in the frequency bands 19.7-20.2 GHz and 29.5-30.0 GHz under certain conditions that are contained in Resolution **156 (WRC-15)**.

Additionally under WRC-19 agenda item 1.5, Resolution **158 (WRC-15)** was adopted directing the ITU-R:

1) to study the technical and operational characteristics and user requirements of different types of ESIM that operate or plan to operate within geostationary FSS allocations in the frequency bands 17.7-19.7 GHz and 27.5-29.5 GHz, including the use of spectrum to provide the envisioned services to various types of ESIM and the degree to which flexible access to spectrum can facilitate sharing with services identified in *recognizing further a)* to *n)*;

2) to study sharing and compatibility between earth stations in motion operating with geostationary FSS networks and current and planned stations of existing services allocated in the frequency bands 17.7-19.7 GHz and 27.5-29.5 GHz to ensure protection of, and not impose undue constraints on, services allocated in those frequency bands, and taking into account *recognizing further a)* to *n)*;

3) to develop, for different types of earth stations in motion and different portions of the frequency bands studied, technical conditions and regulatory provisions for their operation, taking into account the results of the studies above.

This document proposes elements for a preliminary draft new Report on operation of ESIM in FSS allocations at 17.7-19.7 GHz and 27.5-29.5 GHz.

3 Consideration of compatibility

3.1 Allocations in bands 19.3-19.7 GHz / 29.1-29.5 GHz

The Table of Allocations for the bands 19.3-19.7 GHz (space-to-earth) and 29.1-29.5 GHz (Earth-to-space) is provided below:

Allocation to services		
Region 1	**Region 2**	**Region 3**
19.3-19.7	FIXED FIXED-SATELLITE (space-to-Earth) (Earth-to-space) 5.523B 5.523C 5.523D 5.523E MOBILE	
29.1-29.5	FIXED FIXED-SATELLITE (Earth-to-space) 5.516B 5.523C 5.523E 5.535A 5.539 5.541A MOBILE Earth exploration-satellite (Earth-to-space) 5.541 5.540	

The FSS allocations in the bands 19.3-19.7/29.1-29.5 GHz were identified by WRC-95 and WRC-97 for feeder link use for non-GSO MSS systems. The use of the bands 19.3-19.7/29.1-29.5 GHz is subject to footnotes Nos. **5.523B**, **5.523C**, **5.523D**, **5.523E** and **5.535A** of the Radio Regulations. In accordance with these footnotes, GSO FSS and NGSO MSS feeder links operating in the FSS coordinate subject to the application of the provisions of RR No. **9.11A**, i.e. on an equal basis, and RR No. **22.2** does not apply, with the exception of certain legacy GSO FSS systems. Use of these bands by NGSO FSS applications other than NGSO MSS feeder links is subject to RR No. **22.2** (and is not subject to RR No. **9.11A**). RR No. **5.535A** also limits the FSS (Earth-to-space) allocation in the band 29.1-29.5 GHz to geostationary-satellite systems and feeder links to non-geostationary-satellite systems in the mobile-satellite service.

3.2 Criteria for protection of non-GSO MSS feeder links

Criteria for protection of GSO FSS, non-GSO FSS and non-GSO MSS feeder links can be found in Recommendation ITU-R S.1323, "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 co-directional FSS networks below 30 GHz".

For two geostationary networks these criteria are addressed by *recommends* 1 and 2 of Recommendation ITU-R S.1323 and applied using Methodologies in Annex 1 of the Recommendation.

For some non-GSO/FSS systems, the protection criteria are provided in *recommends* 4 of Recommendation ITU-R S.1323 and applied using Methodologies in Annex 1 of the Recommendation.

For non-GSO/MSS feeder links in particular, short term and long term protection criteria for interference from GSO/FSS networks are provided in *recommends* 5, 8 and 9 of Recommendation ITU-R S.1323 and applied using Methodology B (which is deemed to be appropriate for characterizing interference into non-GSO/MSS feeder links) in Annex 1 of the Recommendation. These protection criteria are summarized as: aggregate interference from GSO FSS networks should be responsible for no more than 10% of the time allowance for the BER (or C/N value) threshold short-term performance objective of an NGSO system, and no more than 6% of the total system noise power for more than 10% of the time for the long-term objective[1]. Additionally, for non-GSO links that use adaptive coding, *recommends* 5.2 applies.

The protection criteria provided in Recommendation ITU-R S.1323 *recommends* that the aggregate interference from all other earth and space stations must be addressed. Methodology B in Recommendation ITU-R S.1323 for applying protection criteria to non-GSO/MSS feeder links states that it is "appropriate to apportion $(1/n)$ of the short-term interference time allowance and $(1/n)$ of the long-term interfering signal power to each of the n considered sources of interference and to deal with them separately." From Assumption 3 of Methodology A and Assumptions 2a and 2b of Methodology B of Recommendation ITU-R S.1323, n is related to the number of GSO networks that can potentially cause interference to the non-GSO/MSS feeder links. The maximum number of n is equal to the potentially interfering GSO positions visible, above the minimum operational elevation angle, as observed by the earth station of the non-GSO MSS network. This also implies, for the application considered in this section, that n is constrained to those GSO networks that are within the non-GSO/MSS feeder link service area.

3.2.1 Uplink protection criteria development with respect to static and in motion GSO FSS earth stations

As stated above, Methodology B in Recommendation ITU-R S.1323 provides a method for apportioning short term and long term interference to multiple interference sources. An example of apportioning long term and short interference among n different interference systems is shown in Tables 1a and 1b below. In Tables 1a and 1b, the long term criterion ($I/N = -12.2$ dB for 10% of the time) and short term criterion ($I/N = -3$ dB for 0.01% of the time) are assumed to have already been derived for a particular non-GSO MSS feeder link system based on that system's design performance metrics, as calculated using Methodology B. In practice, the short-term criterion would be based on the particular non-GSO MSS feeder link system characteristics, and would be used by

[1] When applying Methodologies A and A' in Annex 1 or Procedure D in Annex 2 of Recommendation ITU-R S.1323, *recommends* 7 states that long term allowance is not needed.

the parties during coordination discussions. These *I*/*N* values and corresponding percentage of time values represent aggregate interference. In order to derive single-entry protection criterion for each potentially interfering GSO FSS network, these aggregate interference values may be divided equally among the total number '*n' of potentially interfering* GSO space station. In the case of long term interference, the aggregate *I*/*N* value is divided by *n* and the percentage of time is left unchanged. So, as an example in the tables below, if the number of interfering GSO networks is assumed to be 20, *n* would equal 20, which is equivalent to 13 dB, and 13 dB would be subtracted from the *I*/*N* (dB) value. If the number of interfering GSO networks is assumed to be 8, *n* would equal 8, which is equivalent to 9 dB, and 9 dB would be subtracted from the *I*/*N* (dB) value. The actual value depends on the number of GSO space stations that are serving the service area of the non-GSO MSS system. It is also apparent that when assessing protection, *n* must not only take into account currently deployed GSO networks, but future ones likely to be deployed as well. In the case of short term interference, the aggregate percentage of time that the short term *I*/*N* is allowed is divided by *n* and the *I*/*N* value is left unchanged. As in the example in the Table 1a, the short term percentage of time, 0.01% is divided by 20, yielding 0.0005%. In the example in Table 1b, the short term percentage of time, 0.01% is divided by 8, yielding 0.00125%

TABLES 1A AND 1B

Example of apportioning aggregate interference protection criteria to multiple, single-entry interference sources

	Uplink Protection Criteria, Aggregate	
	Short Term	**Long Term**
I/N (dB)	-3	-12.2
% time not to be exceeded	0.01%	10%
	Uplink Protection Criteria, Single Interfering System	
n, number of interfering GSO networks	20 (13 dB)	
I/N (dB)	-3	-25.2
% time not to be exceeded	0.0005%	10%

	Uplink Protection Criteria, Aggregate	
	Short Term	**Long Term**
I/N (dB)	-3	-12.2
% time not to be exceeded	0.01	10%
	Uplink Protection Criteria, Single Interfering System	
n, number of interfering GSO networks	8 (9 dB)	
I/N (dB)	-3	-21.2
% time not to be exceeded	0.00125%	10%

Methodology B also makes clear that, when apportioning interference among *n* interference sources, *n* refers to separate co-frequency GSO networks. GSO networks, taking into account all

earth stations, including ESIM and VSATs, must ensure that aggregate interference from its network does not exceed the allotment of short term and long term interference. How each network determines its aggregate interference should take into account the access technique (MF-TDMA, TDMA, FDMA DAMA-FDMA, CDMA, etc.) and the number of fixed earth stations and ESIM accessing the network operating within the coverage area of the MSS feeder-link receiving beam(s).

Multiple GSO FSS ESIM within the same network may operate within a single non-GSO MSS feeder link channel in multiple ways, either co-frequency at different times, on different frequencies at the same time, or on different frequencies at different times:

– if the GSO FSS channel bandwidth is narrower than the non-GSO MSS feeder link channel bandwidth, Earth stations using FDMA within a GSO FSS network may use multiple channels within the non-GSO satellite receiver channel bandwidth that are simultaneously active, which primarily impacts the long term criteria; and
– if the GSO FSS network uses TDMA, Earth stations within a GSO FSS network may share a given channel in such a way that they are not transmitting simultaneously, which primarily impacts the short term criteria;
– if the GSO FSS network uses CDMA, Earth station within GSO FSS network may use the same channel simultaneously.

These concepts must be accounted for by the GSO FSS network operator to ensure that aggregate interference criteria are met.

These concepts apply equally to ESIM as to fixed Earth stations and are routinely addressed during frequency coordination. From the point of view of frequency coordination, the fact that ESIM are in motion, and hence their locations are variable, is similar to the fact that the locations of VSATs are usually unknown at the time of coordination and often vary throughout the lifetime of a GSO FSS satellite. Hence, coordination has to be done based on appropriate assumptions, e.g. the use of typical or worst case locations.

Figure 1 below illustrates an example non-GSO interference reception zone and depicts three earth stations (two fixed and one aeronautical ESIM) operating with one GSO network. The size, shape and orientation of the three-dimensional interference zone is a function of the relative locations of the non-GSO earth station, non-GSO satellite, GSO earth stations and GSO satellite. For fixed Earth stations the size and shape of the potential interference zone is agreed to between the GSO FSS and NGSO MSS operators, during coordination under RR No. **9.11A**. Typically the result is similar to the red oval shape on the Earth's surface shown in the Figure (however, note that the figure is illustrative and not to scale). This zone may not exist for some GSO ESIM networks that are not operating co-frequency or near the non-GSO MSS feeder link coverage area, whereas for some other GSO ESIM networks the size of the oval will depend on the characteristics of the non-GSO system and GSO network. A coordination agreement could specify operational constraints for GSO FSS ESIM operating co-frequency with NGSO MSS feeder links in that defined area. A similar two-dimensional area would need to be defined for maritime and land ESIM since these terminals operate on the surface of the Earth. For aero ESIM the operating altitudes will be included as part of the potential interference zone, as shown in Figure 1. Annex A presents a methodology to define interference zones at ground level and at 10 000 m.

FIGURE 1

Aggregate uplink interference to non-GSO satellite constellation from static GSO FSS earth stations and GSO FSS ESIM within the same GSO network

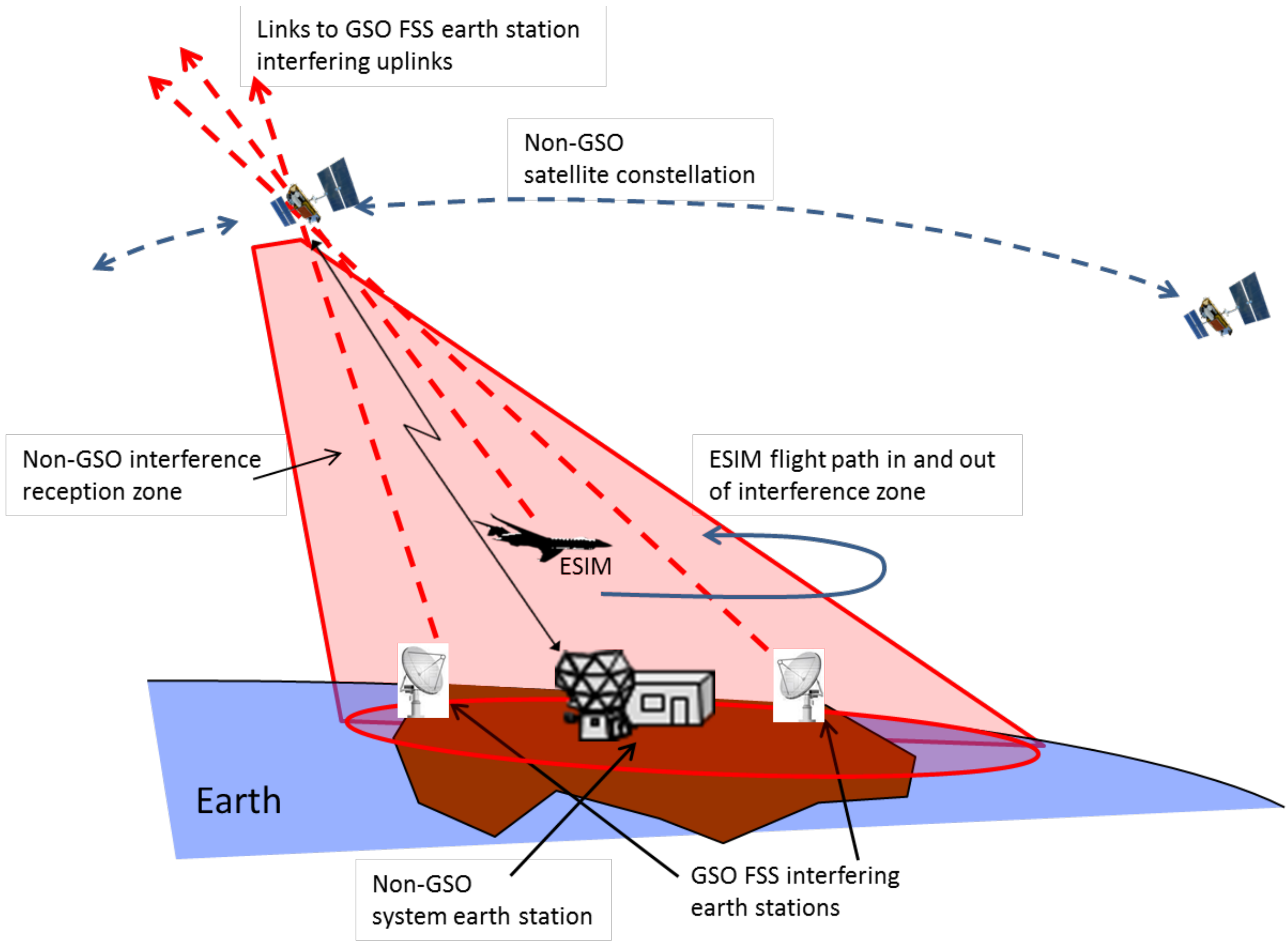


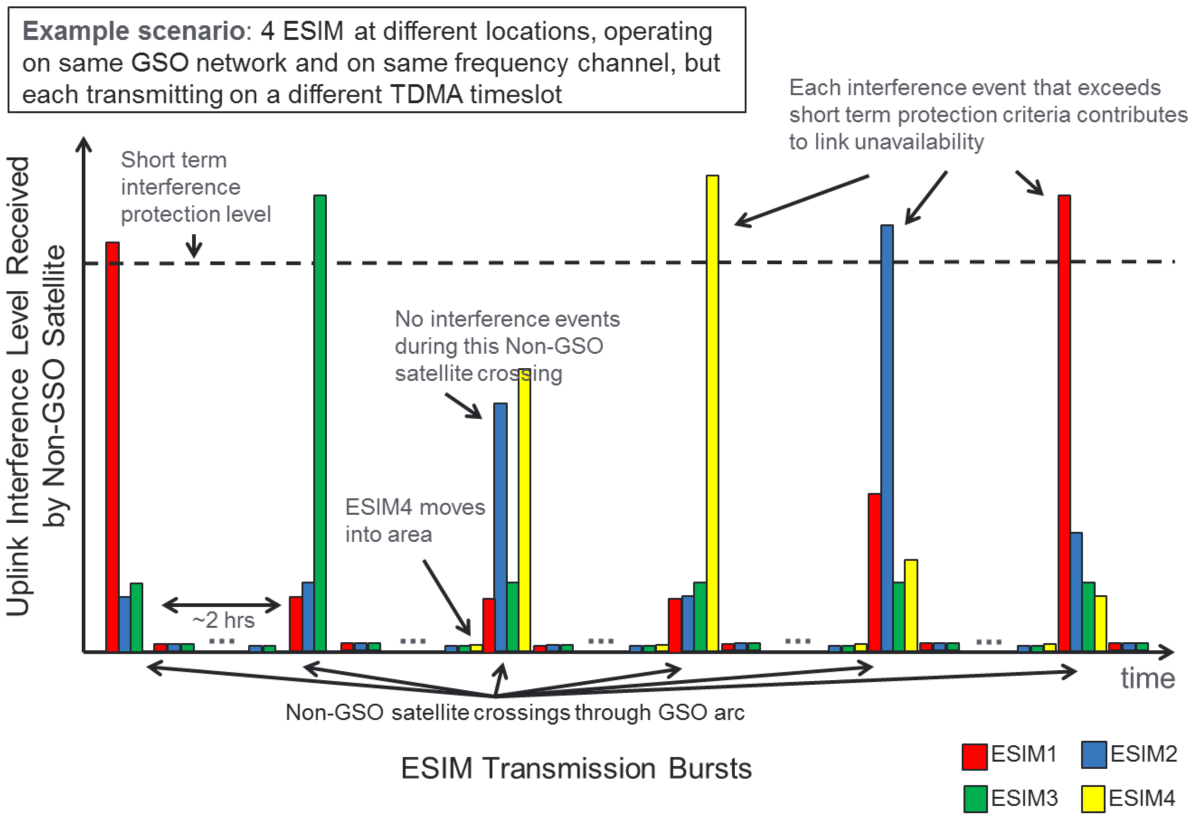
Figure 2 illustrates the effect of time-varying interference sources on the non-GSO MSS feeder link short term protection criterion. The represented non-GSO MSS system has six satellite planes with polar orbits such that satellites within a given plane cross through the GSO arc about every eight minutes. Additionally, since the planes are fixed in space relative to the Earth's position, the rotation of the Earth results in a new orbital plane passing over a given fixed point on Earth approximately every two hours. As a result, from the perspective of the non-GSO feeder link earth station, opportunities for in-line interference events relative to a GSO satellite occur approximately every two hours, as depicted in Figure 2.

In the example shown, four ESIM terminals are in motion near the non-GSO earth station. Typically, the terminals are not generating significant interference during periods when the non-GSO satellite is not passing through the GSO arc (or more accurately, when it's not passing through an ESIM main beam to a GSO satellite in the GSO arc). When the non-GSO satellite does pass through a portion of the GSO arc, interference events may occur from one (or more) ESIM. Interference from multiple earth stations, whether they are ESIM or fixed earth stations, does not occur simultaneously, unless several earth stations are transmitting in the same location. In the scenario illustrated in Figure 2, each of four ESIM contributes short-term interference over time that affects the non-GSO MSS feeder link availability. The figure also shows that there are times in which the non-GSO satellite passes through the GSO arc but no interference events occur, since that portion of the GSO arc is not near where the receiving GSO satellite is located.

The figure also shows that there are times when the non-GSO MSS satellite is passing through the GSO arc, but one ESIM has moved further away from the non-GSO MSS feeder link earth station and therefore has no opportunity to create a short term interference event. Conversely, there are also times when additional ESIM could move closer to the feeder link earth station and generate additional interference events. However, for both ESIM and fixed earth stations, the maximum number of interfering earth station is bounded by the frequency channelling and time multiplexing arrangements of the GSO FSS network and non-GSO MSS system. Another factor to consider in relation to short-term interference is the time percentage of the short-term criterion, which is based on the overall length of time the criterion is exceeded ("interference duration").

FIGURE 2

Example of ESIM generating time varying short term interference events



The example in Figure 2 shows the mobile, time-varying nature of the number of ESIM that may be in a region around the non-GSO MSS feeder link earth station. These factors would need to be taken into account to define a potential interference zone for the GSO FSS network using ESIM for situations in which the ESIM has radio line of sight to the non-GSO satellite serving the non-GSO MSS feeder link earth station. Other factors, such as pointing angles of the ESIM and of the MSS feeder link receiving beam, would need to be considered as well. Annexes A and B illustrate example methodologies to define such interference zones based on the protection criteria of the non-GSO MSS feeder link system. When implementing protection measures, it will be necessary for the GSO network to which these ESIM belong to verify that the aggregate interference from the ESIM are meeting the non-GSO MSS feeder link system's short term protection criterion.

In order to better understand the interference impact in the above scenarios, it is useful to determine the maximum number of ESIM and fixed earth stations that can be supported by a given GSO FSS network over a given GSO satellite and/or beam footprint coverage area. Since the contribution of a

single ESIM interferer can be determined, and a likely maximum number of possible ESIM can also be determined in a given area, then a bound on the maximum long-term and short-term interference can be derived and compared to the criteria.

A given GSO network has its own allotment of allowable interference to meet the non-GSO MSS feeder link short term and long term protection criteria. As discussed in the previous section, it is straightforward to calculate a GSO fixed earth station's interference contribution, provided that its location is known, since its interference is a function of its location. For a fixed earth station in an unknown location and for an earth station that is mobile, it is unknown, *a priori,* whether it will generate an interference event at the non-GSO satellite, since the occurrence of an interference event is a function of where that earth station is relative to the moving non-GSO satellite at a given point in time. The interference analysis therefore needs to take into account the actual locations, including altitude, of the earth stations (if they are known) or consider that the earth station could be operated at any location within a defined area.

As discussed above, potential interference zones around the non-GSO earth station are affected when the ESIM is an aeronautical terminal flying at altitude over the Earth's surface. Therefore, for aeronautical ESIM the potential interference zone needs to take into account the altitude of the aircraft.

3.2.2 Downlink protection criteria development with respect to static and in motion GSO FSS earth stations

In the case of downlink protection criteria for MSS feeder links of non-GSO systems, the aggregate interference is apportioned among *n* number of interfering GSO satellites. Downlink transmissions from GSO satellites that serve fixed earth stations also support ESIMs. As no changes to GSO downlink transmissions are necessary to support ESIM operations, no ESIM-specific measures are needed in coordination of GSO networks

3.2.3 Interference Mitigation Techniques

As described above the FSS allocations in the bands 19.3-19.7/29.1-29.5 GHz were identified by WRC-95 and WRC-97 for feeder link use for non-GSO MSS systems subject to coordination with GSO FSS under RR No. **9.11A**. Prior to this identification the ITU-R conducted studies on the compatibility between non-GSO MSS feeder links and GSO FSS networks and adopted Recommendation ITU-R S.1419, "Interference Mitigation Techniques to Facilitate Coordination Between non-GSO MSS Feeder links and GSO FSS networks in the bands 19.3-19.7 GHz and 29.1-29.5 GHz". This Recommendation among other things describes mitigation techniques that can be implemented by operators of NGSO MSS feeder links and GSO FSS networks to achieve compatibility and satisfactory coordination outcomes. The techniques include adaptive power control, use of high gain antennas, geographic isolation between earth stations, satellite diversity, site diversity and link balancing. These techniques maybe useful and could be taken into account under this agenda item.

3.3 Technical conditions and regulatory provisions for operation of ESIM in bands 19.3-19.7 GHz / 29.1-29.5 GHz

Non-GSO MSS feeder links have been operating for almost 20 years in portions of the 19.3-19.7 GHz (space-to-Earth) and 29.1-29.5 GHz (Earth-to-space) frequency bands with GSO FSS links. Through bilateral coordination under RR No. **9.11A** between administrations operating GSO FSS networks and NGSO MSS feeder link systems, compatibility is maintained taking into account ITU-R Recommendations regarding protection criteria, methodologies and mitigation techniques.

During the bilateral coordination process, analyses are conducted to define operational constraints that will allow compatible operations between the GSO FSS and non-GSO MSS feeder link systems using short-term and long-term interference criteria applicable to non-GSO MSS feeder links and interference criteria for GSO FSS stations as agreed to between the administrations. During the coordination administrations may also take into account various interference mitigation techniques that can be employed including adaptive power control, the use of high gain antennas, geographical isolation between earth stations, satellite diversity, orbital predictions, frequency diversity and site diversity.

In coordination, to ensure protection of the operations of non-GSO MSS feeder links based on long term and short term *I/N* values and their corresponding percentages of times, boundaries need to be defined where operational constraints are required. Such a boundary would consist of geographical points at which a hypothetical interfering ESIM just meets the single-entry protection criteria.

Since ESIMs will operate while moving this will require that the operator of the ESIM has the capability to control some of the ESIM characteristics based on its location (e.g., transmit power and frequency) to ensure that any relevant regulatory restrictions developed are maintained.

4 Summary

[Editor's note: Two options are provided for this section to reflect the different views.]

[Option 1:

Ongoing compatibility studies between GSO networks employing ESIM and non-GSO MSS feeder link systems should determine the interference criteria and resolve technical issues related to assessing the impact of time-varying ESIM interference within the framework of Recommendation ITU-R S.1323. These compatibility studies may lead to new regulatory restrictions, and may also enable the potential interference between ESIM operating with GSO FSS stations and non-GSO MSS feeder links in the 19.3 19.7 GHz (space-to-Earth) and 29.1-29.5 GHz (Earth to space) band to be resolved under the existing coordination procedures of No. **9.11A** of the Radio Regulations.

This will allow Administrations to take into account specific parameters of the type of ESIM deployments in adopting suitable regulatory, technical and operational constraints on ESIM operations to ensure that non-GSO MSS feeder links are protected. Under this framework it will be necessary for the ESIM operator to have the capability to control the ESIM characteristics (e.g., transmit power, frequency, location) to ensure that any relevant regulatory restrictions developed are maintained.

Option 2:

This Report has discussed the interference criteria for non-GSO MSS feeder links and methods to achieve compatibility between GSO networks employing ESIM and non-GSO MSS feeder link systems in the 19.3-19.7 GHz (space-to-Earth) and 29.1-29.5 GHz (Earth-to-space) band under the existing coordination procedures of No. **9.11A** of the Radio Regulations.

The material in this Report can be used by Administrations during frequency coordination and will allow Administrations to take into account specific parameters of ESIM deployments in adopting suitable technical and operational constraints on ESIM operations to ensure that non-GSO MSS feeder links are protected. Under this framework it will be necessary for the ESIM operator to have the capability to control the ESIM characteristics based on its location (e.g., transmit power, frequency) to ensure that constraints agreed to in coordination, are met and that non-GSO MSS feeder links are protected.]

Annex A presents a methodology to define interference zones at ground level and at 10 000 m.

Annex B is one example of a simulated scenario of non-GSO MSS feeder links and aeronautical ESIMs operating within a GSO network. It calculated the I/N levels and associated percentage of time for the particular case examined.

ANNEX A

Method for coordination between earth stations in motion (ESIM) and NGSO MSS feeder links in the 29.1-29.5 GHz band

Overview

This Annex addresses possible coordination methods for ESIMs with NGSO MSS feeder links. The Annex demonstrates that one method that is currently used for the coordination between NGSO MSS feeder links operating in the 29.1-29.5 GHz band and ubiquitous fixed earth stations is equally applicable for earth station in motion (ESIM), including aero ESIMs.

NGSO MSS feeder link stations are at known locations and the number of stations is limited. Typically coordination between GSO FSS and NGSO MSS feeder link operators results in an exclusion zone around the NGSO MSS feeder link station where FSS earth stations will not operate. This coordination approach is well known and has been used for years. Maritime and land ESIMs that operate on the Earth's surface can be coordinated using exactly the same methods that are used to coordinate fixed earth stations. Exclusion zones for aero ESIMs can also be determined with minor changes to these methods and the exclusion zones will very closely resemble those for fixed earth stations.

The analysis presented here is conservative but demonstrates the feasibility of coordination under near worst-case assumptions. In practice, actual inter-operator coordination may utilize more specific inputs and more realistic assumptions, which would lead to more favorable coordination outcomes, i.e. smaller exclusion zones.

Analysis

The analysis consists of simulations that produce statistics of interference from ESIMs to NGSO MSS feeder uplinks. The simulation analysis was performed for earth stations on the ground and for aero ESIMs at an altitude of 10 km. Simplified exclusion zones were generated using eight sample points in different azimuth directions relative to the NGSO MSS feeder link gateway. Multiple FSS earth stations are assumed to be transmitting co-frequency with the NGSO MSS feeder link earth station. The ESIMs are assumed to be static and operating continuously – this approach is over-simplified and will result in a conservative estimate of the exclusion zone since ESIMs are actually mobile and may not transmit continuously. In order to determine ESIM locations that fulfil the assumed I/N criteria, simulations were run with the ESIMs located at different points along the chosen azimuth. The simulations were performed using 500 ms time step and a 15 day duration along with the NGSO MSS feeder link and GSO parameters shown below.

NGSO MSS system parameters

– Height: 780 km
– Inclination angle: 86.4 degrees
– No. of satellites per plane: 11
– No. of planes: 6

- Satellite separation within plane: 32.7°
- Satellite phasing between planes: 31.6°
- Minimum elevation: 8°
- Satellite rx antenna gain: 30.1 dBi
- System noise temperature: 1295 K
- Antenna gain pattern: Rec. ITU-R S.465-5

NGSO MSS Feeder Link Earth Station

- Example location at 33°N, -111°E

NGSO MSS Feeder Link Carrier Parameters

- Bandwidth: 7.5 MHz
- No. of carrier: 1

Interference Criteria

- Based on Rec. ITU-R S.1323

GSO Satellite Parameters

- Orbital location: 150°W

GSO FSS Earth Station

- Altitude: 0 m (Land terminal), 10 km (Aero ESIM)
- Tx gain: 43.4 dBi (60 cm diameter)
- Antenna pattern: Rec. ITU-R S.580-6
- Maximum p.s.d: -56.5 dBW/Hz

GSO FSS Carrier Parameters

- Bandwidth: 2.5 MHz
- No. of carriers: 3

Results

The figure below shows the exclusion zones for the two cases: land terminal and aero ESIM at an altitude of 10 km. The land and aero ESIM exclusion points are shown in black and red respectively. As can be seen the difference between the exclusion zones for land and maritime ESIM and aero ESIM is extremely small –less than 0.3% difference in total area. The detailed difference in the distances and area are shown in the Tables 1 and 2 below.

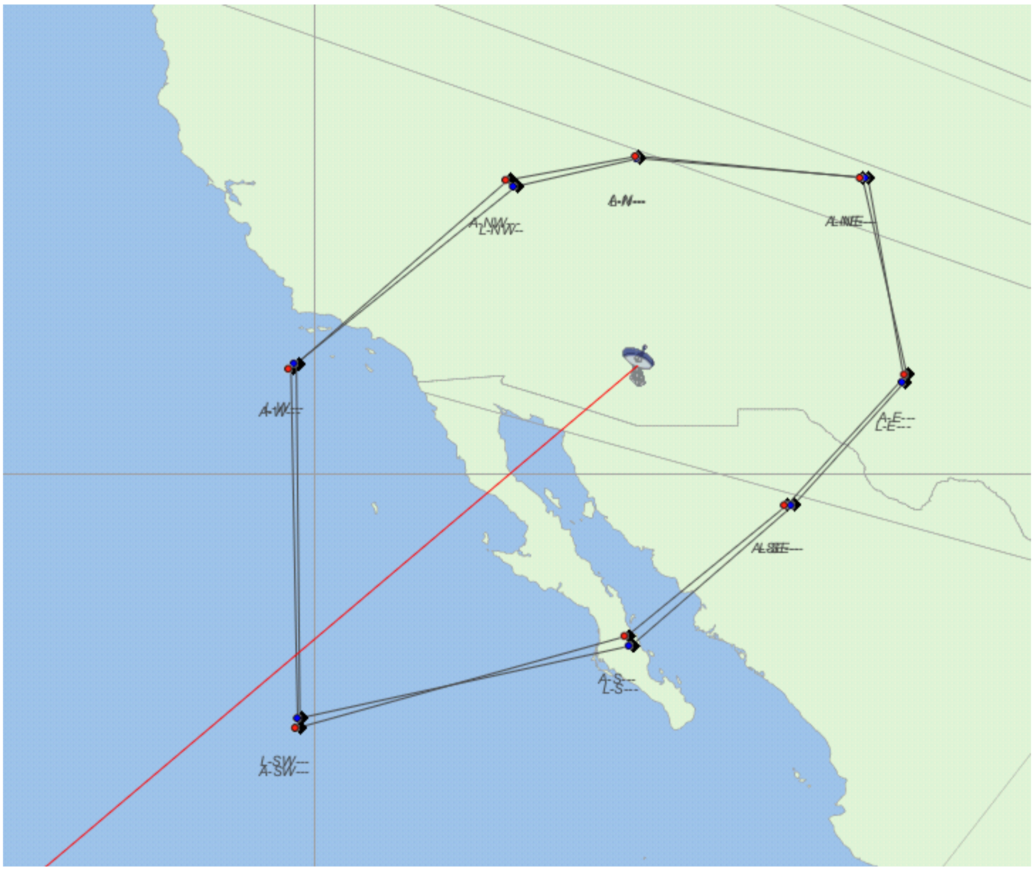


Table 1 shows the distance (on the ground) from the exclusion zone test points to the NGSO MSS feeder link earth station and Table 2 shows the difference in the exclusion zone areas for the land and maritime earth stations and aero ESIM.

TABLE 1

Direction	**Land/Maritime UT (km)**	**Aero ESIM (km)**	**Delta (L/M to Aero) (km)**	**Delta %**
North	640.8	647.2	6.4	+1.0%
North east	818.6	810.3	-8.3	-1.0%
East	696.4	699.3	2.9	+0.4%
South east	597.5	585.8	-11.7	-2.0%
South	866.6	837.5	-29.1	-3.4%
South west	1425.4	1455.2	29.8	+2.1%
West	885.9	900.9	15.0	+1.7%
North west	633.1	659.7	26.6	+4.2%

TABLE 2

Land.Maritime UT (km^2)	**Aero ESIM (km^2)**	**Delta (L/M to Aero)**	**Delta %**
1 953 334	1 958 971	-5 637	+0.3%

Conclusions

The analysis provided in this Annex is conservative, but demonstrates that coordination between ESIMs and non-GSO MSS feeder links is feasible and that existing methods that are used in coordination for fixed VSAT networks can also be used for ESIM. Actual coordinated exclusion zones will depend on the specific GSO characteristics, protection criteria of the NGSO MSS feeder link and other assumptions that would be agreed upon between the operators/administration during coordination under RR No. **9.11A**.

ANNEX B

Study for analyzing compatibility between airborne ESIM and non-GSO MSS feeder links in the 29.1-29.5 GHz band

To simulate the effects of a number of aeronautical ESIMs operating within multiple GSO networks, the Iridium MSS feeder link was modeled in Visualyse Pro software using the notified characteristics of the HIBLEO-2FL system.[2] The simulation also included a number of ESIMs using characteristics representative of those stations that will operate with the ViaSat-2 satellite. The characteristics used in the simulation for the HIBLEO-2FL and for the ESIMs are given in Tables 1 and 2 below.

TABLE 1

HIBLEO-2FL Characteristics

Parameter / Description	Value
Satellites	66 with orbital characteristic per HIBLEO-2FL filing
Orbital planes / satellites per plane	6 planes / 11 satellites per plane
Orbital height	780 km
Orbital inclination	86.4°
Orbital period	100 min
Feeder link frequency (uplink)	29.1-29.3 GHz
Feeder link polarization (uplink)	RHCP
Satellite FL beam receive antenna gain	30.1 dBi
Satellite FL beam antenna pattern	S.465
Satellite FL beam receive system noise	1295 K
Satellite FL beam G/T (calculated)	-1.02 dB/K
Feeder link emission designator	4M38Q7W
Earth station tracking scheme	Tracking based on longest hold time with 5° minimum elevation at earth station
Tracked earth station	Tempe, AZ

[2] The US has filed additional coordination requests for the HIBLEO-2FL System. These are HIBLEO-2FL2 and HIBLEO-2FL2 Mod-1. This analysis only considers filings that are currently brought into use and additional studies may be required to address the new HIBLEO-2FL2 filings once Notified.

HIBLEO-2FL Assumptions

The HIBLEO-2FL system is assumed to be operating using the Tempe, AZ gateway earth station, and per advice from the operator, that the earth station is tracking the desired satellites using a longest hold time strategy with a minimum elevation at the earth station of 5° above the local horizon. The output power of the gateway earth station was not considered as this analysis only examines received I/N at the spacecraft and does not consider C/I, C/N, or C/(N+I).

TABLE 2

ESIM Characteristics

Antenna diameter (major axis)	78 cm
Antenna gain	40.5 dBi
Antenna input power	14 dBW
e.i.r.p density per carrier (single per ES)	35.5 dBW/MHz
Carrier emission designator	80M0G7D
Carrier frequency	29.2 GHz
Carrier polarization	RHCP
Carrier burst duty cycle	6%
ESIMs in simulation	24
ESIMs per GSO satellite	6
Target GSO satellite locations	-107, -89, -79, -55

Aeronautical ESIM assumptions

- The ESIMs are representative of those of one satellite network operator and may not be representative of ESIMs used with other satellite networks.
- The ESIMs are assumed to each operate on the same frequency (29.2 GHz) and that this is both co-frequency and co-polar to the HIBLEO-2FL feeder link channel being evaluated.
- ESIMs are operating at 10.7 km and flying at normal cruise speeds.
- Each ESIM is traveling between a city pair for which the flight path will cross over or near the Tempe, AZ gateway facility.
- At the conclusion of each flight within the simulation, the flight restarts and repeats the previous flight path. This continues for the duration of the simulation.
- The simulated ESIM antenna patterns take into account variations due to skew angle.

Analysis

The analysis runs over a 30-day simulation period in a step size of one second.

In each step, the positions of the Iridium satellites in the constellation are updated and the pointing angle between the Iridium gateway and the tracked satellite are updated, as is the pointing of the satellite's receiving beam toward the gateway. The locations of the ESIMs are updated by using the define variable feature in Visualyse to update the latitude and longitude of the stations according to a table of waypoints for each station.

As the ESIMs move through the simulation, they burst according to the settings for each in the traffic module of Visualyse. In this simulation the ESIMs are all configured with a burst duty cycle of 6%. The 6% duty cycle is calculated asynchronously for each earth station. Accordingly, in the simulation, there is a small possibility that multiple earth stations may burst at the same time. In a real MF-TDMA network, multiple co-frequency co-time bursts will not occur in a given satellite beam.

Figure 1 shows a snapshot of the ESIM locations at one point in time of the simulation. The figure also shows a snapshot of the -3 dB receiving beam contour on the earth at a given point in time. In this snapshot approximately six ESIMs are within the receiving beam.

FIGURE 1

Simulation Map View

In the simulation, each ESIM will transmit to one of four GSO satellites defined in the simulation. The orbital locations used were 107 W.L., 89 W.L., 79 W.L, and 55 W.L. The target GSO satellite for each ESIM is fixed for the duration of the simulation.

Given the city pair sets chosen for each ESIM, the length of time required for the flights to complete vary, leading to variable times of the day over which the flights cross over or near the Tempe, AZ gateway. Also, because of the variable flight lengths, the density of aircraft over or near the gateway vary during the simulation.

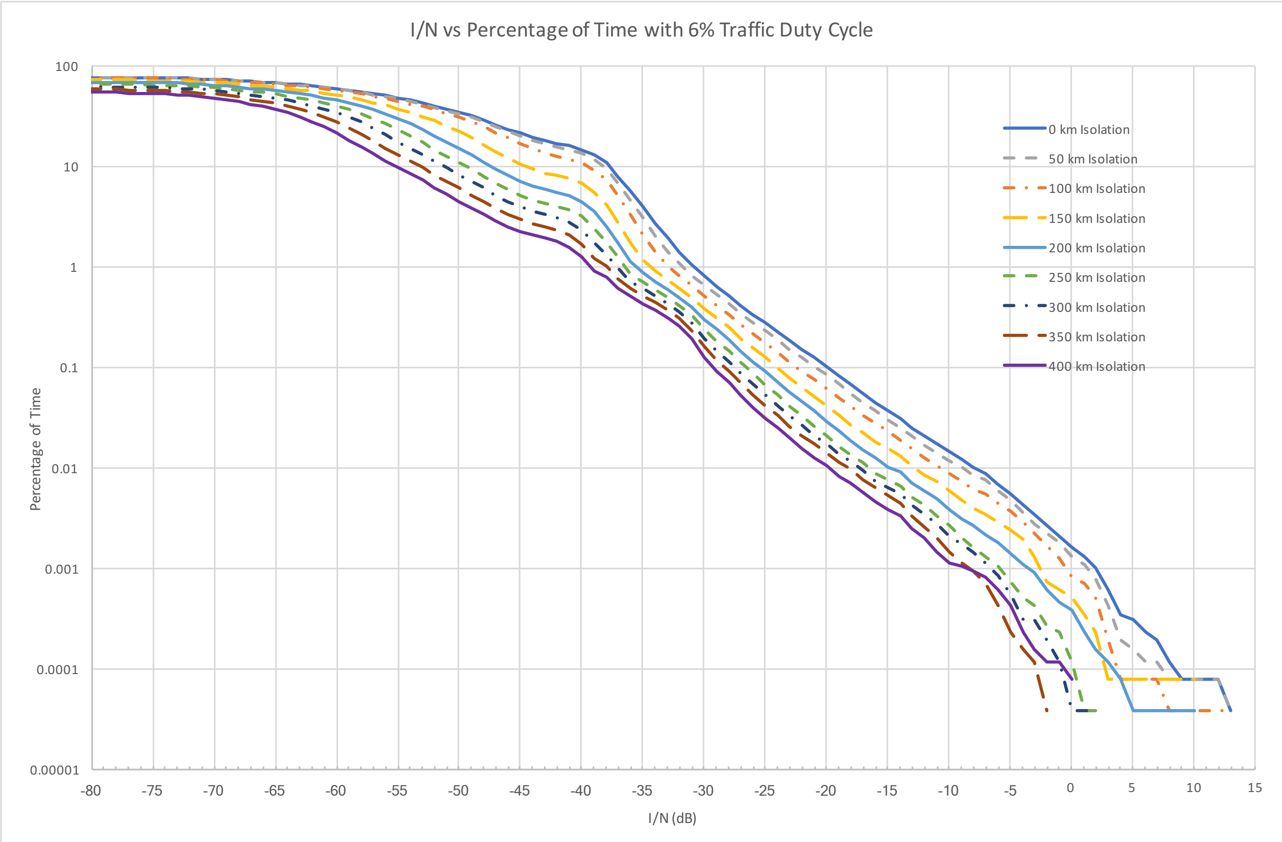
It is worth noting that, in the simulation, the ESIM flights continue unabated 24 hours per day over the length of the 30-day simulation, unlike actual commercial air flight operations, which have a cycle over a given day with some flights starting in the morning and building during the day, then dropping off overnight. This is in contrast to land or maritime ESIMs which may be in the vicinity of the gateway over long periods depending on their operational characteristics.

The same Visualyse traffic module used to control the burst duty cycle also allows for use of an isolation zone around a station where transmissions from that particular bursting station are not allowed. Multiple simulations were run using various circular isolation zones from 0 km to 400 km in 50 km steps.

Figure 2 shows the results of these simulations and depicts the CDF of the I/N as a percentage of time.

FIGURE 2

CDF of I/N vs Percentage of Time



Summary of study

The long term aggregate I/N of -12.2 dB for 10% of the time is never exceeded. The long term single entry I/N of -18.2 dB for four GSO systems is also never exceeded, even with no isolation zone over the gateway.

Given that the simulation reports an I/N of approximately -37.5 dB 10% of the time even with no isolation zone with the aggregate transmissions of four GSO ESIM networks, which is 25.3 dB less than the target goal, it is obvious that no isolation is needed to meet the long term criteria for the four GSO networks used in this example simulation.

For short term I/N and % time criteria, Figure 2 shows a sensitivity analysis of impact of size of circular isolation zones on received interference.

It should also be noted that the curves in Figure 2 represent results based on the characteristics of one GSO operator, and that entirely different sets of curves could be obtained by changing ESIM terminal transmission characteristics, the number of ESIMs, as well as the operational flight patterns, altitudes and frequency of flights for these ESIMs.

The range, variation and limits of these parameters are areas for potential additional studies to help provide a basis for determining an accurate zone where operational controls may be required.

Similar, future studies involving land and marine ESIMs are needed to determine compatibility with non-GSO MSS feeder links.

DECLARATION

I hereby declare that I am the technically qualified person responsible for preparation of the engineering information contained in the foregoing *Ex Parte* Response of Viasat, Inc. to Iridium in IB Docket No. 17-95 ("*Ex Parte* Response"), that I am familiar with Part 25 of the Commission's rules, that I have either prepared or reviewed the engineering information submitted with this *Ex Parte* Response, and that it is complete and accurate to the best of my knowledge, information and belief.

Daryl T. Hunter, P.E.
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August 29, 2018