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18 January 2018

<u>Ex Parte</u>

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

Re: *Amendment of Parts 2 and 25 of the Commission's Rules to Facilitate the Use of Earth Stations in Motion Communicating with Geostationary Orbit Space Stations in Frequency Bands Allocated to the Fixed Satellite Service*; IB Docket No. 17-95

Dear Ms. Dortch:

As Iridium has explained throughout this proceeding, the satellite industry, despite years of trying, has been unable to develop a means of determining whether ESIMs operating in constant and unpredictable motion around an NGSO MSS earth station will interfere with the feeder-link operations of large NGSO satellite constellations. As a result, it would be premature to adopt new rules that authorize ESIMs to operate in the same frequencies as NGSO MSS feeder links, as some GSO FSS operators have urged the Commission to do. These new rules would put networks like Iridium's at risk of harmful interference, and would discourage companies from investing in new NGSO systems in the mobile-satellite service. They also would require the Commission to insert itself more deeply into the coordination process than it is equipped to do, by forcing it to resolve complex disputes over how to define exclusion zones within which ESIMs must not operate.[1]

Moreover, even assuming the Commission succeeds in accomplishing what the industry has been unable to achieve on its own, the best-case outcome of the coordination process would be very large exclusion zones that prevent ESIMs from operating in shared spectrum across much of the United States and its surrounding areas. And even after the Commission defines exclusion zones for each and every GSO network, the Commission would still have to confront the difficult question of whether, in the case of ESIMs, exclusion zones of such magnitude can be reliably enforced.

Those are the risks. Where are the rewards? Of the 2,000 MHz in new spectrum being considered for ESIMs, only 50 MHz (2.5%) is shared with NGSO MSS feeder links in the U.S. and raises the unique challenges described above. That 50 MHz lies entirely in the 29.25-29.3 GHz band, which NGSO MSS operators have co-primary rights to use for their feeder links, and which GSO operators are prohibited from using for ESIMs. On that basis, Iridium has urged the Commission to proceed with its ESIMs proposal, but to exclude the 29.25-29.3 GHz band from

[1] *See* Comments of SES S.A. and O3B Limited at 10, IB Docket No. 17-95 (filed July 31, 2017) (suggesting that the Commission "define a perimeter around Iridium earth stations within which coordination is necessary").

its order—a common-sense adjustment that would protect new and existing mobile satellite services without materially impacting ESIM deployments.

Inmarsat and ViaSat resist this common-sense approach. In a recent joint pleading,[2] each operator claims to have developed over the past few months what has eluded the entire industry for the better part of the last decade: an interference analysis purporting to confirm that ESIMs operating outside of a predefined exclusion zone can coexist with Iridium's constellation. But what they have actually presented to the Commission is nothing of the sort.

First, neither analysis overcomes the unique complexity introduced by ESIM interference, which is the constant and unpredictable motion of ESIM terminals. As Iridium has explained, the mobility of ESIMs makes it impossible to model whether multiple ESIM terminals transmitting from unknown locations will, in the aggregate, generate in-line events often enough to cause unacceptable interference into NGSO satellites. ViaSat simply cherry-picks some among many possible paths that an ESIM might take. Inmarsat fails to recognize the problem altogether, by modeling only whether ESIMs transmitting from *fixed* locations will generate interference. Both approaches drastically understate interference into NGSO satellites.

Second, having entirely ignored the actual problem posed by ESIMs, ViaSat and Inmarsat proceed to deal from the bottom of the deck with technical assumptions that are demonstrably incorrect. ViaSat's transmit, receive, and usage parameters bear no resemblance to the real world—or to ViaSat's own filings, for that matter—and once again understate interference substantially. Inmarsat's assumptions, on the other hand, defy the laws of Euclidean geometry.

Finally, flawed as they are, these analyses actually manage to get one thing right. They both demonstrate that authorizing ESIMs in the 29.25-29.3 GHz band would be a fool's errand. *ViaSat's underlying methodology concedes that interference can only be modeled if the precise path of each potentially interfering ESIM is known, which of course is a practical impossibility.* And even after understating the interference problem, *Inmarsat's analysis concludes that an exclusion zone of 750,000 square miles per GSO network per Iridium feeder-link earth station would be required to prevent harmful interference into the Iridium network*—a concession that, in the scheme of an item that would provide close to 2,000 MHz in new ESIM spectrum, makes one wonder why anyone is wasting time debating ESIMs in this 50 MHz band.

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[2] *See* Letter from M. Ethan Lucarelli, Director, Regulatory & Public Policy, Inmarsat, Inc., Giselle Creeser, Director, Regulatory, Inmarsat, Inc., and John P. Janka and Elizabeth R. Park, Counsel to ViaSat, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission, IB Docket No. 17-95 (filed Nov. 6, 2017) ("ViaSat/Inmarsat Joint Ex Parte").

I. IMPROBABLE INTERFERENCE SCENARIOS: NEITHER ANALYSIS ACCOUNTS FOR ESIMS' UNPREDICTABLE MOBILITY.

As Iridium has explained,[3] ESIMs create in-line interference at the Iridium satellite receiver whenever one of Iridium's sixty-six satellites passes through the ESIM terminal's main beam. Each in-line event that exceeds the Iridium satellite's maximum tolerated interference level contributes to the unavailability of Iridium's feeder links, and to the potential disruption of critical services. Though every in-line event is concerning, some can occur without impairing Iridium's service availability. The real question is whether the in-line events occur frequently enough to breach the network's short-term protection criterion, which tolerates relatively high levels of short-term interference provided they do not occur very often.

The answer to that question depends on the number of ESIMs transmitting in a given region, their specific locations relative to each Iridium earth station and satellite over time (i.e., their paths of motion), and the number and frequency of these paths. The problem with ESIMs, however, is that they are in constant and unpredictable motion, so their numbers and locations over time cannot be known. Neither ViaSat nor Inmarsat even *begins* to address this problem.

A. ViaSat

ViaSat's interference analysis attempts to determine whether ***six*** aeronautical ESIMs would cause unacceptable interference into the Iridium system. But instead of accurately modeling the ESIM-to-NGSO interference scenario, *ViaSat makes cherry-picked assumptions about the path of each ESIM that grossly oversimplify the real world*.

ViaSat's simulation assumes that six ESIMs are in what it calls "[t]ypical ESIM motion."[4] To ViaSat, "typical ESIM motion" means that each ESIM transmits from airplanes on "flights between" unspecified "city pairs," and move with an unstated "speed" and at a "nominal altitude" of 35,000 feet. [5] Not only does ViaSat fail to specify the speed and "city pairs" that it assumes, or recognize that altitude obviously varies during a flight, it also fails to build-in other critical features of the interference environment created by ESIMs. For example, does each ESIM fly directly over the Iridium earth station, or at some distance away? When precisely is each ESIM at cruising altitude, as opposed to ascending from or descending to an airport? How

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[3] *See* Comments of Iridium Satellite, LLC at 9–11, IB Docket No. 17-95 (filed July 31, 2017) ("Comments of Iridium"); Reply Comments of Iridium Satellite, LLC at 3, IB Docket No. 17-95 (filed Aug. 30, 2017) ("Reply Comments of Iridium"); Letter from Scott B. Harris, Counsel to Iridium Communications, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission (filed Sept. 25, 2017); Letter from Scott B. Harris, Counsel to Iridium Communications, Inc., to Marlene H. Dortch, Secretary, Federal Communications Commission (filed Oct. 13, 2017).

[4] ViaSat/Inmarsat Joint Ex Parte at Attachment p. 5.

[5] *Id.*

many such flights are there in a given timeframe—only ***six***? According to the National Air Traffic Controllers Association, there are over ***87,000*** flights over the United States every day.[6] How many simultaneous flights on different inter-city routes are there in the region? To what extent can ESIM motion even be described as "typical," given various deployment scenarios and the complexity of the aviation, ground transportation, and maritime shipping routes that serve the United States?

Self-evidently, all of these variables will affect whether in-line events generated by the six ESIMs assumed by ViaSat will breach Iridium's short-term criterion. For example, ViaSat's interference results clearly would differ for six ESIM-equipped aircraft flying over an Iridium feeder-link earth station every hour as compared to one ESIM-equipped aircraft flying from coast to coast 200 miles to the north of the Iridium earth station once a day. Indeed, using ViaSat's approach, it would be just as easy to create a modeling scenario showing that harmful interference occurs almost constantly, as it was for ViaSat to create a fictitious world in which interference barely occurs at all.

B. Inmarsat

Inmarsat's analysis takes a different fantasy approach, but fares no better. Inmarsat attempts to define an exclusion zone from scratch. To do so, Inmarsat uses an iterative, trial and error method to calculate, for eight different azimuths, an adequate separation distance from the Iridium gateway.[7] Those iterations produced eight points on earth around the Iridium gateway, which defined a polygon that Inmarsat took to be the final (and very large) ESIM exclusion zone. The problem is that Inmarsat's simulations determine each separation distance by modeling an individual ESIM that transmits from a given *fixed* location (i.e., from a point along one of the eight azimuths).[8] But in reality, each GSO satellite likely will communicate with multiple ESIMs in the region, and other GSO satellites also will communicate with multiple ESIMs in the region. Those other, moving ESIMs will create their own interference events independently at different times, and each of those events *also* will contribute to the breach of Iridium's short-term protection criterion. Thus, when determining the separation distance for each ESIM being simulated, Inmarsat failed to account not only for the movement of that ESIM, but also the impact on the interference produced by the other, moving ESIMs in the area.

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6 *Tracking the 87,000 Flights per Day*, Right This Minute, http://www.rightthisminute.com/video/tracking-87000-flights-day.

7 For each azimuth, the iterative model selected a distance from an Iridium earth station, and then ran an interference simulation to see if the proposed separation distance met the Iridium network's protection criteria. The model would re-run the simulation for smaller and larger separation distances until it arrived at a minimum distance below which harmful interference would occur. *See* ViaSat/Inmarsat Joint Ex Parte at Attachment p. 15-18.

8 *See* ViaSat/Inmarsat Joint Ex Parte at Attachment p. 15-16.

Incredibly, Inmarsat touts this fatal flaw as a feature, claiming incorrectly the assumption that ESIMs are "static and operating continuously" *overstates* the separation distances required.[9] This is actually a long-term interference analysis in a short-term interference world, and demonstrates Inmarsat's complete misunderstanding of the interference concern here. As Iridium explained several times in its comments and reply comments, the concern with ESIMs is *not* that the sum of received power from multiple ESIM terminals interfering simultaneously will overload the Iridium satellite receiver. It is that multiple ESIMs moving in view of an Iridium gateway will generate an in-line event each time any of Iridium's sixty-six satellites crosses any of the ESIMs' main beams, and that those in-line events, ***in the aggregate***, will breach the Iridium feeder link's availability and short-term protection criterion, which only permits bursts of short-term interference for a very small percentage of time.[10] Had Inmarsat accounted for multiple ESIMs, the frequency of occurrence of short-term interference events would have increased dramatically—meaning that, in the real world, Inmarsat's already very large exclusion zone would *expand* even larger by an unknown amount and in unknown directions.

In short, by incorrectly assuming that multiple ESIMs can be accounted for independently instead of in aggregate, Inmarsat has not simplified the world, but fictionalized it. The resulting analysis understates interference by a large degree, and must be rejected by the Commission.

II. INCORRECT INPUTS: EACH ANALYSIS UNDERSTATES INTERFERENCE BY RELYING ON PLAINLY ERRONEOUS TECHNICAL PARAMETERS

As explained above, the interference scenarios modeled by ViaSat and Inmarsat drastically understate the interference problem if ESIMs are introduced into NGSO MSS feeder link spectrum. Both operators then compound that error by relying on unrealistic and objectively incorrect technical assumptions that further understate the potential for interference.

A. ViaSat

To determine whether ESIMs operating within a given exclusion zone will produce unacceptable interference, any analysis must make certain assumptions about the characteristics of the interfering terminals and the receive antenna on each Iridium satellite. ViaSat's assumptions are demonstrably false, and result in a further significant underestimation of the interference problem.

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[9] *Id.* at Attachment p. 15.

[10] Reply Comments of Iridium at 7 (explaining that "while the number of simultaneously operating ESIMs can be useful in determining whether a GSO network exceeds the long-term protection criterion, it is of no value in verifying compliance with the short-term protection criterion. This is because the short-term protection criterion is driven by the aggregate number of individual interference events that a network's ESIMs generate over time, and not the aggregate interference levels created when a network's ESIMs interfere at the same time); *see also* Comments of Iridium at 14-16 and Figure 2.

1. ESIM transmit characteristics

First, ViaSat relies on favorable ESIM transmit characteristics that are not only internally inconsistent, but also inconsistent with ViaSat's prior filings. For example, ViaSat's conclusion that ESIMs present no threat of interference to Iridium relies in part on inconsistent ESIM EIRP values and less sensitive Iridium satellite receivers. ViaSat assumes that its ESIM terminals transmit with an EIRP of 43.5 dBW.[11] That figure is inconsistent with the transmit characteristics assumed in another part of the *very same analysis*. Indeed, just five slides earlier, ViaSat states that its ESIM terminals will have a maximum power output of 25W and an antenna gain of 40.5 dBi—which equate to a maximum EIRP of 54.4 dBW.[12] Moreover, as part of its advocacy for more ESIM spectrum, ViaSat has contributed documents to the ITU-R describing ESIM terminal parameters. Those documents list a range of EIRP values from 38.9 to 46.8 dBW for aeronautical ESIM terminals.[13] With all of these different assertions, there is no way to know the actual transmit power of a ViaSat ESIM terminal.

It gets worse. ViaSat also understates the interference problem by assuming a carrier bandwidth of 80 MHz. But in its submissions to the ITU-R, ViaSat states that its aeronautical ESIM users operate in significantly smaller bandwidths in the range of just 781.25 kHz to 6.25 MHz, while maintaining the same range of EIRP values noted above.[14] ViaSat's curious selection of a much wider carrier bandwidth for the purpose of modeling interference to Iridium results in an EIRP density that is artificially reduced by as much as 20 dB,[15] and thereby understates the potential interference caused by ESIM terminals by as much as 20 dB. To say that ViaSat has modeled a "best case" scenario would be an understatement. *Since ViaSat's parameters seem to change for different audiences, there is literally no way to know if its modeling has any connection to the real world whatsoever.*

2. Unrealistically low terminal usage

In its interference analysis, ViaSat assumes that the duty cycle of each ESIM is 6%, or in other words, that each ESIM is only transmitting 6% of the time. Remarkably, ViaSat describes this as "heavy terminal usage."[16]

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[11] ViaSat/Inmarsat Joint Ex Parte at Attachment p. 9.

[12] *Id.* at Attachment p. 4.

[13] ITU-R WP4A Document 4A/500, *Operation of earth stations in motion (ESIM) in fixed-satellite service allocations at 17.7-19.7 Ghz and 27.5-29.5 GHz – protection criteria for feeder links of the MSS in the bands 19.3-19.7 GHz and 29.1-29.5 GHz* at 12, Table 1 (Oct. 13, 2017) ("ITU-R WP4A Document 4A/500"); ITU-R WP4A Document 4A/501, *Operation of earth stations in motion (ESIM) communication with geostationary space stations in the fixed-satellite service allocations at 17.7-19.7 GHz and 27.5-29.5 GHz* at 15, Table 3 (Oct. 12, 2017).

[14] ITU-R WP4A Document 4A/500 at 12, Table 1.

[15] The difference in EIRP density, in dB, between 80 MHz and 781.25 kHz is equal to 10*log(80/0.78125) = 20.1 dB.

[16] ViaSat/Inmarsat Joint Ex Parte at Attachment p. 5.

Yet again, ViaSat distorts its analysis by using a convenient assumption that departs dramatically from prior submissions. In documents submitted to ITU-R, ViaSat performed compatibility simulation studies for ESIMs under *100% duty cycle* conditions.[17] Those studies showed that the resulting interference (I/N) under a 100% duty cycle assumption would be 14 dB higher than under a 4% duty cycle.[18] The same analytical rigor should have been applied here, especially given the nascent status of ESIMs and their potential for future growth. Indeed, if ESIMs will transmit at most 6% of the time, it strongly suggests that the vast 2,000 MHz of spectrum requested for ESIMs may exceed the actual need—and reducing that 2,000 MHz by the 50 MHz at issue here would not be a problem for prospective ESIM operators.

3. Iridium satellite receiver sensitivity

In addition to understating transmit power, transmit power density, and terminal usage, ViaSat chose to understate the sensitivity of the Iridium satellite receiver. In its interference analysis, ViaSat assumes that each Iridium satellite receiver has a sensitivity (G/T) of -1.0 dB/K.[19] But this value holds true for Iridium's first-generation satellites only. It does not account for the improved technology of Iridium's second-generation satellite constellation, Iridium NEXT, which already has been approved by the Commission.[20] As provided in the Iridium NEXT Schedule S, Iridium NEXT satellites—thirty of which are already in orbit—are far more sensitive, with a maximum receiver sensitivity (G/T) of 2.5 dB/K.[21] The Iridium NEXT satellites are therefore 3.5 dB more sensitive to interference, meaning that yet another technical parameter built into ViaSat's simulation substantially understates the interference problem. When considering the fact that ViaSat may have underestimated its interference EIRP densities by 20 dB (in addition to confusion over what the actual EIRP values are), underestimated its terminals' duty cycles by another 14 dB and then understating Iridium satellite receiver sensitivity by another 3.5 dB, ViaSat's analysis appears to be incorrectly assessing ESIM interference potential by 37.5 dB.

B. Inmarsat

As Iridium has described,[22] aeronautical ESIMs pose even greater challenges than ESIMs on ships or vehicles with respect to defining an accurate exclusion zone. This is because the

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[17] ITU-R WP4A Document 4A/462, *Sharing and compatibility between earth stations in motion operating in geostationary FSS networks and current planned stations of the FS in the frequency band 27.5-29.5 GHz* at 9 (Oct. 10, 2017) ("For example, an ESIM typical duty cycle for a 90MHz channel is 4%. The simulations are done for ESIM return links duty cycles of 100% for worst case and 4% for typical case").

[18] *Id.* at 19, Table 6.

[19] *See* ViaSat/Inmarsat Joint Ex Parte at Attachment p. 4; (-1.0 dB/K is calculated from the listed Iridium satellite antenna gain of 30.1 dBi and Iridium satellite receiver system noise temperature of 1295 K).

[20] *See Iridium Constellation LLC Application for Modification of License to Authorize a Second-Generation NGSO MSS Constellation*, Order and Authorization, 31 FCC Rcd. 8675, 8688 ¶ 42 (2016).

[21] *See* Application of Iridium Constellation, LLC, IBFS File No. SAT-MOD-20131227-00148, at Attachment Schedule S DOC 1-3.

[22] Comments of Iridium at 16-17.

interference produced by aeronautical ESIMs depends on their altitude, which means a three-dimensional exclusion zone must be defined and enforced. Iridium is not aware of any standard method for defining, let alone enforcing, these exclusion zones, and therefore does not understand how it can be claimed that coordination with aeronautical ESIMs might occur.

Inmarsat attempts to trivialize this issue by asserting it has figured out how to derive a 3D exclusion zone.[23] Though the details of Inmarsat's calculations are scarce, it appears that Inmarsat simply modeled the interference created by a single, fixed aeronautical terminal at 10 km in altitude, and then proceeded to define an exclusion zone the same way as it did for terrestrial ESIMs—the only difference being that the ESIM is at 10 km altitude at each of the eight azimuth points, which results in a slightly larger exclusion zone that extends vertically above the Earth.[24]

This is just not how geometry works. As Iridium has explained, the actual 3D exclusion zone will be the composite of various *cone-shaped* interference reception zones oriented towards the receiving Iridium satellite. As a result, the exclusion zone at any particular altitude may extend further away from the Iridium gateway than if the ESIM were on the Earth's surface. Or, to put it another way, the exclusion zone size is not constant with altitude—it varies with altitude. Yet again, Inmarsat has oversimplified its analysis to sidestep the complexity of having to accurately define an ESIMs exclusion zone. No operator reasonably could be asked to place the reliability of its network on the line based on Inmarsat's fictionalized hypothetical.

III. BOTH ANALYSES DEMONSTRATE THE WISDOM OF THE CURRENT EXCLUSION OF ESIMS FROM THE 29.25-29.3 GHZ BAND

Beneath the many deficiencies of the interference analysis provided by ViaSat and Inmarsat lies a truer big picture: solving the ESIM-to-NGSO interference problem would be an incredibly difficult task—and, even assuming it could be done, the result would not be worth the effort.

ViaSat's analysis recognizes that, in order to model ESIM-to-NGSO interference accurately, the path of each potentially interfering ESIM must be known ahead of time. This is precisely what Iridium has been trying to explain for years. But instead of acknowledging that ESIMs move constantly and unpredictably, ViaSat made oversimplified and unrealistic assumptions about where each ESIM will be located over time (and used misleading transmit, usage, and receive inputs to further understate the resulting interference). The lesson from ViaSat's analysis is not only that unreasonable assumptions produce unreliable results, but also that there are too many unknowns to determine where ESIMs will produce unacceptable interference, because the concept of "typical ESIM motion" is a farce. Until and unless that changes, authorizing ESIMs in bands shared with NGSO MSS feeder-links would be premature and counterproductive.

Inmarsat's analysis, despite its flaws, is also instructive. As described above, Inmarsat understates interference by failing to account for the aggregate effect and mobility of ESIMs, and

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[23] *See* ViaSat/Inmarsat Joint Ex Parte at Attachment p. 16-18.

[24] *Id.* at 15.

by incorrectly modeling exclusion zones at altitude. Despite the downward bias, the outcome of Inmarsat's analysis is an exclusion zone that is still incredibly large: 753,000 square miles would be unavailable to ESIMs around *each* of Iridium's feeder-link earth stations. Iridium currently operates three feeder-link earth stations in the 29.25-29.3 GHz band in the United States. Thus, even if Inmarsat's analysis were correct, ESIMs would be unable to operate in the 29.25-29.3 GHz band over more than *2.25 million square miles* of the United States and its surrounding areas, an area equal to more than 70% of the land mass of the lower 48 states (including Washington, D.C.).

Importantly, Inmarsat's exclusion zone was calculated for just one GSO satellite network communicating with a space station at 150° W. Yet an Iridium gateway, because it must see down to a 5-degree elevation angle, will see (with 2 degree spacing) 69 different GSO satellites along the GSO arc. Additional exclusion zones, oriented in different directions around each Iridium earth station, would have to be defined for ESIMs that communicate with satellites located in different positions along the GSO arc. The resulting composite exclusion zone for all GSO networks would be much, much larger than the exclusion zone for the particular GSO network assumed by Inmarsat, and would narrow the area over which ESIMs can operate in the 29.25-29.3 GHz band even further. Thus, the interference analysis presented by Inmarsat merely underscores the unreasonableness of its position.

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There is no reason for the Commission to gamble on the flawed analyses presented by ViaSat and Inmarsat. The 29.25-29.3 GHz band has just 50 MHz—or 2.5%—of the new ESIM spectrum being considered by the Commission, to say nothing of the 1,000 MHz of spectrum in which ESIMs *already* are permitted. Moreover, according to Inmarsat's own analysis, ESIM operators would be unable to use the spectrum across much of the United States in any event. One has to wonder why ViaSat and Inmarsat are making such a fuss about such a small amount spectrum. One has to wonder whether the real value to them of this spectrum is that it is used by a competitor operating a network with an inherent design advantage: low latency arising from low earth orbit. One has to wonder whether the primary reason for seeking this particular sliver of spectrum is to put a competitor's operations at risk.

Regardless of the motivations involved, instead of putting Iridium and the commercial, military, civilian government, and scientific users that it serves at risk, the Commission should defer action on the 29.25-29.3 GHz band until the industry can develop a *credible* method of avoiding harmful interference into NGSO MSS networks.

Sincerely,

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