

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554**

<i>In the Matter of</i>)	
)	
AUDACY CORPORATION	)	File No. SAT-LOA-20161115-00117
)	
THE BOEING COMPANY	)	File No. SAT-LOA-20161115-00109
)	
KAROUSEL LLC	)	File No. SAT-LOA-20161115-00113
)	
LEOSAT MA, INC.	)	File No. SAT-PDR-20161115-00112
)	
O3B LIMITED	)	File No. SAT-AMD-20161115-00116
)	
SPACE EXPLORATION HOLDINGS, LLC	)	File No. SAT-LOA-20161115-00118
)	
SPACE NORWAY AS	)	File No. SAT-PDR-20161115-00111
)	
TELESAT CANADA	)	File No. SAT-PDR-20161115-00108
)	
THEIA HOLDINGS A, INC.	)	File No. SAT-LOA-20161115-00121
)	
VIASAT, INC.	)	File No. SAT-PDR-20161115-00120

CONSOLIDATED REPLY OF SPACE EXPLORATION HOLDINGS, LLC

Space Exploration Holdings, LLC (“SpaceX”) hereby replies to the responses to comments filed with respect to the above referenced license applications and petitions for U.S. market access, which are currently pending in the processing round for non-geostationary orbit (“NGSO”) satellite systems in the Fixed-Satellite Service (“FSS”) using certain Ku- and Ka-band spectrum.¹ In its comments in many of these proceedings, SpaceX focused primarily on two issues: (1) the need to provide NGSO system operators with incentives to design systems capable of efficiently and equitably sharing spectrum

¹ See Public Notice, “Applications Accepted for Filing,” 32 FCC Rcd. 4180 (IB 2017).

resources, and (2) the potential for powerful uplink transmissions to overwhelm receivers on low-Earth orbit (“LEO”) satellites even outside of an in-line event. While responses varied in their formulation, they amounted to a similar refrain – the Commission need not consider such issues because spectrum sharing can be worked out in coordination negotiations. As discussed below, this response does not adequately address the issues raised.

Contrary to some responses, SpaceX does not propose that the Commission give all available spectrum to SpaceX to the exclusion of others.² Rather, SpaceX merely seeks to ensure that valuable spectrum is put to use efficiently for the benefit of the American public. To this end, no NGSO system should be forced to bear the entire burden in coordinating spectrum sharing arrangements, as the resulting inefficiency would deny consumers in underserved areas the benefits of high-quality broadband services. The Commission will promote the public interest by setting expectations for equitable and efficient spectrum sharing as it acts upon the pending applications.

A. THE COMMISSION SHOULD SET EXPECTATIONS FOR EQUITABLE AND EFFICIENT SPECTRUM SHARING

The spectrum at issue in this NGSO processing round is a valuable public resource. Accordingly, the Commission must ensure that NGSO operators use this resource efficiently to achieve a sufficient level of benefits for the public. Some proposed systems operate much less efficiently than others. For example, Theia proposes to use 500 MHz of downlink spectrum per satellite to deliver 62.6 Mbps of throughput to users,³ which is

² See, e.g., Karousel LLC’s Response to Comments and Opposition to Petitions, IBFS File No. SAT-LOA-20161115-00113, at 2-3, 7 (“Karousel Response”). Unless otherwise indicated, all responses cited in this Reply were filed on July 7, 2017.

³ See Theia Application, IBFS File No. SAT-LOA-20161115-00121, Technical Narrative at 29 and App. 3 at 3 (filed Nov. 15, 2016).

orders of magnitude less capacity than other NGSO systems expect to generate in the same spectrum. Moreover, Theia provides little information on how its system will operate, which makes analysis of its proposal difficult.⁴ Similarly, Audacy requests 500 MHz of Ka-band spectrum in each direction for TT&C links in “off-nominal, emergency situations.”⁵ Such a large amount of spectrum seems entirely disproportionate to the proposed usage, and what little is disclosed about the characteristics of Audacy’s system raises significant interference concerns to the extent it operates in this spectrum outside of true emergencies.

In its various comments, SpaceX noted one particular inefficiency applicable to several proposed NGSO systems. Specifically, those systems envision the use of large, static spot beams, which will reduce spectral efficiency by increasing the frequency and duration of in-line events.⁶ In response, parties made two arguments. First, they argued that large beams do not increase the effect of in-line events. For example, O3b argues that such events are “a simple function of geometry,”⁷ while Boeing similarly asserts that the incidence of in-line events is “a function of the orbital angular alignment of the satellites.”⁸ While that may be true from the earth station’s perspective, this argument glosses over the fact that large beams covering earth stations in a large area for relatively long periods

⁴ For example, Theia now asserts that its system will operate with up to 19 dB of rain margin, but does not explain the clear sky power levels it will target – a key parameter to allow other operators to determine the potential interference implications of the system. *See* Consolidated Opposition and Response, IBFS File No. SAT-LOA-20161115-00121, at 28 (“Theia Response”)

⁵ Audacy Corporation, IBFS File No. SAT-LOA-20161115-00117, Application at 44 (filed Nov. 15, 2016).

⁶ *See, e.g.*, Comments of Space Explorations Technologies Corp., IBFS File Nos. SAT-LOA-20161115-00109, at 2-3 (“Comments on Boeing”), SAT-AMD-20161115-00116, at 2-3 (“Comments on O3b”), and SAT-PDR-20161115-00120, at 2-4 (“Comments on ViaSat”) (June 26, 2017).

⁷ Opposition and Response of O3b Limited, IBFS File No. SAT-AMD-20161115-00116, at 4-5 (“O3b Response”).

⁸ Opposition and Response, IBFS File No. SAT-LOA-20161115-00109, at 6 (“Boeing Response”).

experience more in-line events than do smaller beams. For the benefit of delivering one channel of data, they affect potential delivery of many times more bandwidth from the same spectrum reused over and over again by smaller beams covering the same area. More importantly, if the operator of a system with a large beam cannot arrive at an agreement for spectrum sharing with any one of the other operators whose satellites are in-line within a beam, it must revert to band splitting with respect to that entire beam – even in areas that would not have been affected (or could have been coordinated) had it deployed a narrower beam. This will have adverse consequences not only for the NGSO operators involved, but also for the public that will be denied robust broadband service due to the inefficient spectrum usage.

A related problem arises with NGSO satellites that have a large footprint, as they can create “false” in-line events because other NGSO operators must assume that beams are operating throughout the entire footprint even when, in fact, no beam is being used for service to a given location.⁹ False in-line events are even more problematic than real ones because they lead NGSO operators to take steps that reduce overall spectral efficiency to avoid interference that would not have actually occurred even without such measures. In order to address this problem, SpaceX proposed that operators share data with other NGSO operators to indicate the steering angle of each beam within the footprint. By enabling both operators to identify which apparent in-line events are false, this data would reduce the number of instances in which those operators would potentially face band splitting.

As illustrated below, this is a win-win for the operators and for the public interest in spectrum efficiency. Figure 1 shows the area within the footprint of a single ViaSat satellite potentially subject to in-line interference events with SpaceX satellites. Because

⁹ See, e.g., Comments on Boeing at 3-4; Comments on ViaSat at 3-4.

SpaceX must assume that ViaSat is providing service using any beam within the satellite's coverage footprint, the area (in red) where in-line events appear likely, depending on the position of SpaceX earth stations, is quite large – which means that the number of cases for which the two operators must either coordinate or engage in inefficient spectrum splitting is also quite large. This would significantly and unnecessarily reduce total bandwidth for both operators, and thereby deny the public the full benefit of spectrum use.

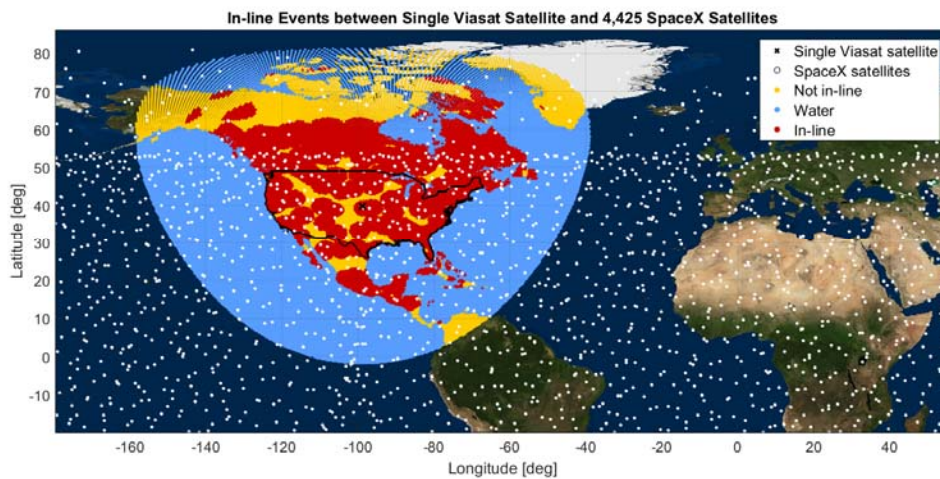


Figure 1. In-Line Events Without Shared Information

Figure 2 shows the same area, this time assuming that ViaSat has provided information on where it has actually steered its 16 Ka-band beams to provide service.

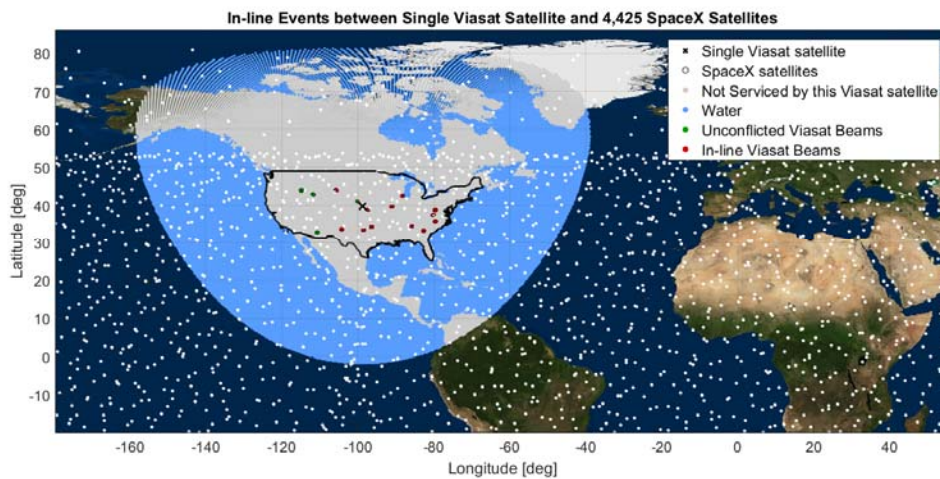


Figure 2. In-Line Events Using Shared Information

As this figure shows, such information sharing results in a dramatic decrease in the area where the operators must resolve in-line events.

Boeing recognizes the potential benefits of such an approach, and appears to support the information sharing proposal.¹⁰ However, O3b opposes it on the grounds that it calls for exchange of commercially sensitive information, and that SpaceX has not volunteered to provide such information for its own system.¹¹ Yet NGSO operators will likely need to exchange a significant amount of information to support both physical and frequency coordination, and can devise non-disclosure arrangements to accommodate that process. Beam steering information is no different. SpaceX is willing to collaborate with other NGSO operators by providing information to identify true in-line events and thereby avoid inefficient band splitting that would constrain broadband service offerings.

The second argument raised in response to SpaceX is the assertion that these sorts of issues can and should be resolved through operator-to-operator coordination. SpaceX acknowledges that NGSO operators will need to engage in extensive coordination. But the description of how such coordination would be achieved highlights SpaceX's concern, as it appears that many commenters would place most or all of the burden of accommodating less capable NGSO systems upon more capable NGSO systems, such as that proposed by SpaceX. For example, O3b argues that band splitting would not be required during in-line events with SpaceX satellites, since the SpaceX system has sufficient satellite diversity to work around such issues.¹² Similarly, ViaSat argues that unwanted energy from its system would not necessarily have an impact on SpaceX's system because SpaceX has a high level

¹⁰ See Boeing Response at 7.

¹¹ See O3b Response at 6.

¹² See O3b Response at 5.

of satellite diversity.¹³ Going even further, Space Norway asserts that it is reasonable for the Commission to require large, global NGSO constellations to carry the entire burden of avoiding in-line events with smaller NGSO systems, such as by observing a separation angle of 22 degrees or more at all times with respect to the Space Norway system.¹⁴ Notably, no party supported Space Norway’s self-serving proposal for special protection of its particular NGSO system.

As it considers how to resolve the applications pending in this NGSO processing round, the Commission should take the opportunity to set expectations for equitable and efficient spectrum sharing going forward. SpaceX strongly supports application of the avoidance of in-line events regime to all bands at issue here. But the Commission should make clear that all parties must be willing to bear their fair share of the burden of coexistence, and that no one NGSO system should be expected to take an inordinate share because it has been designed to include greater technical capabilities than another. Given that the default in the absence of agreement is band splitting, the Commission could promote the interests of spectral efficiency by establishing how it expects coordination to proceed so that all interested parties are operating from a common understanding.

B. POWERFUL UPLINK TRANSMISSIONS POSE A SIGNIFICANT THREAT TO LEO OPERATIONS

SpaceX also demonstrated that proposed NGSO systems that operate with very high EIRP in their systems’ earth station uplink beams are likely to cause interference whenever a LEO satellite passes through the main beam or sidelobe of that transmission.¹⁵ This is

¹³ See Consolidated Opposition and Reply Comments of ViaSat, Inc., IBFS File No. SAT-PDR-20161115-00120, at 14 (“ViaSat Response”).

¹⁴ See Response of Space Norway AS to Comments and Opposition to Petitions to Deny, IBFS File No. SAT-PDR-20161115-00111, at 7-10 (“Space Norway Response”).

¹⁵ See, e.g., Comments on Boeing at 4-7; Comments on O3b at 3-7; Comments on ViaSat at 4-8.

particularly likely to be the case with respect to NGSO systems operating at higher altitudes, such as MEO and HEO systems. In response, several operators argue that SpaceX's analysis overstates the problem, and that NGSO system operators can explore ways to mitigate any interference concerns during coordination negotiations.¹⁶ Yet that does not assure resolution of an issue that is structurally geared to result in interference given the system parameters in the pending applications. This EIRP disparity presents a significant challenge to the operation of LEO systems in the presence of HEO and MEO systems.

SpaceX intends to present additional evidence on this issue in the ongoing rulemaking to update the rules for NGSO systems.¹⁷ It thus requested that, at a minimum, the Commission condition any grant of the relevant applications upon compliance with any spectrum sharing requirements adopted in that proceeding. No operator has argued that it should not be subject to such a condition.

C. BRIEF SUPPLEMENT ON THREE ISSUES

Three issues addressed in SpaceX's Response were also discussed in responses filed by other parties. Without repeating its prior arguments, SpaceX briefly supplements its response on those three issues below.

- Hughes and Intelsat join OneWeb in opposing SpaceX's request for limited waiver of the implementation milestone requirement and the domestic geographic coverage

¹⁶ See, e.g., Boeing Response at 7-8; Opposition and Response of LeoSat MA, Inc., IBFS File No. SAT-PDR-20161115-00112, at 8-9 ("LeoSat Response"); O3b Response at 5-6; Space Norway Response at 8-10; Theia Response at 28-30.

¹⁷ See *Update to Parts 2 and 25 Concerning Non-Geostationary, Fixed-Satellite Service Systems and Related Matters*, 31 FCC Rcd. 13651 (2016) ("NGSO NPRM").

requirement.¹⁸ In addition to its prior response on these issues,¹⁹ SpaceX would add that, because SpaceX has made a particularized showing that the requested relief is appropriate in the specific circumstances of this case, it would not be appropriate for the Commission to defer consideration of these issues to the *NGSO NPRM* proceeding as Intelsat suggests.

- In its Response, SpaceX fully addressed ViaSat’s concerns with respect to the adequacy of the Commission’s EPFD regime, and rebutted ViaSat’s argument that the Commission should impose a condition that would make all NGSO operators jointly and severally liable for aggregate EPFD compliance.²⁰ Seven other applicants in this NGSO processing round similarly opposed ViaSat’s arguments, which are better addressed in the context of the *NGSO NPRM*.²¹
- Several other applicants also joined SpaceX in opposing Telesat’s attempt to block competing applications on the grounds that their systems could cause harmful interference to Telesat’s system in derogation of its asserted priority under ITU rules.²² Like SpaceX, those applicants support the Commission’s avoidance of in-line interference regime, which yields more efficient spectrum sharing results than a regime based solely upon ITU priority. Nonetheless, none of those applicants

¹⁸ See Letter from Jennifer A. Manner to Marlene Dortch, DA 17-524, at 3-4 (July 7, 2017); Reply Comments of Intelsat License LLC, IBFS File Nos. SAT-LOA-20161115-00118 and -00109, at 2-5.

¹⁹ See Consolidated Opposition to Petitions and Response to Comments of Space Exploration Holdings, LLC, IBFS File No. SAT-LOA-20161115-00118, at 18-25 (“SpaceX Response”).

²⁰ See *id.* at 26-27.

²¹ See, e.g., Opposition and Response of Audacy Corporation, IBFS File No. SAT-LOA-20161115-00117, at 8-9; Boeing Response at 12-13; Karousel Response at 10 n.24; O3b Response at 8-9; Space Norway Response at 10-11; Telesat Canada’s Opposition to the Petition to Deny or Impose Conditions of ViaSat, Inc., IBFS File No. SAT-PDR-20161115-00108, at 2-4 (July 7, 2017); Theia Response at 20.

²² See, e.g., SpaceX Response at 16-17; Boeing Response at 11-12; O3b Response at 1-3; Karousel Response at 7-9; Space Norway Response at 2-3; Theia Response at 18-19; ViaSat Response at 15.

rejected imposition of a standard condition requiring compliance with ITU coordination processes. However, as Boeing pointed out, accepting such a condition does not “equate to precedence in NGSO interference events based on ITU priority and there is significant diversity of opinion regarding the role of ITU precedence in any interference mitigation approach required by the Commission’s rules.”²³

* * *

SpaceX agrees with commenters that emphasize the importance and flexibility of the coordination process. But effective coordination depends on a regulatory backdrop that encourages parties to reach coordination agreements that are equitable and promote efficient use of spectrum. SpaceX looks forward to working with the Commission and interested parties to develop and implement such a framework.

Respectfully submitted,

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July 14, 2017

²³ See Boeing Response at 11-12.

CERTIFICATE OF SERVICE

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