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

In the Matter of	)	
	)	
Gogo LLC	)	File No. SES-MOD-___________
	)	Call Sign E120106
Modification to Blanket License for Operation of Ku-Band Transmit/Receive Earth Stations Aboard Aircraft	)))	

MODIFICATION

Gogo LLC ("Gogo") hereby requests a modification of its blanket license to operate Ku-band transmit/receive earth stations aboard aircraft ("ESAAs") on domestic and international flights.[1] Gogo requests that the Commission modify the Gogo ESAA License by adding the following spacecraft as authorized points of communication: AMC-1; Galaxy 17; Intelsat 18; Eutelsat 115 West B; Eutelsat 117 West A; JCSAT-2B; JCSAT-5A; Yamal 300K; Yamal 401; and AsiaSat 7.

A narrative description of the relevant changes is provided here, and Gogo is attaching an FCC Form 312 and Schedule B that identify the new points of communication and provide updated technical parameters for the ESAA operations. Supplemental technical information and copies of relevant coordination letters are attached as well. Pursuant to Section 25.117(c) of the Commission's rules, Gogo is providing herein information that is

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[1] *Gogo LLC*, Call Sign E120106, File No. SES-MFS-20140801-00625, granted Dec. 22, 2014 (the "Gogo ESAA License").

changing as a result of the modification. Gogo certifies that the remaining information provided in support of the Gogo ESAA License has not changed.[2]

I. ADDITIONAL SATELLITES

Gogo requests modification of its license to add AMC-1 as a point of communication for the Gogo ESAA network pursuant to the provisions of Section 25.227(a)(1) and (b)(1), and to add the Galaxy 17; Intelsat 18; Eutelsat 115 West B; Eutelsat 117 West A; JCSAT-2B; JCSAT-5A; Yamal 300K; Yamal 401; and AsiaSat 7 satellites as points of communication for the Gogo ESAA network pursuant to the provisions of Section 25.227(a)(2) and (b)(2). As discussed below, each of the requested satellites is eligible for authority for use with the Gogo ESAA network.

Furthermore, upon the addition of the satellites requested herein, Gogo will no longer be using the Satmex-5 satellite for its ESAA operations, so that satellite can be removed from the Gogo license. Updated tables listing the satellites to be used and the associated ground stations are provided in Annex 2 hereto.

AMC-1: AMC-1 is a U.S.-licensed satellite positioned at the 129.15° W.L. orbital location,[3] and complete technical information regarding the satellite is therefore already on file with the Commission. Gogo seeks authority to use AMC-1 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and in the 11.7-12.2 GHz downlink

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2 For the Commission's convenience, Gogo has attached as Annex 1 hereto a table listing the information required pursuant to Section 25.227 of the Commission's rules and providing a cross-reference to the necessary information.

3 *See SES Americom, Inc.*, Call Sign S2445, File Nos. SAT-MOD-20140730-00089 & SAT-AMD-20150219-00006, grant-stamped May 28, 2015.

spectrum, consistent with the Commission's orders in the ESAA proceeding[4] and with the terms of the satellite license.

AMC-1 will provide coverage of North America. Because AMC-1 was recently relocated to 129.15° W.L., SES has advised Gogo that coordination of the satellite at the location has not yet been completed. Accordingly, pending coordination Gogo seeks authority to operate with AMC-1 pursuant to Section 25.227(a)(1) and (b)(1). A demonstration that the Gogo antennas will comply with the off-axis EIRP spectral density specified in Section 25.227(a)(1)(i)(A) in the plane of the geostationary satellite orbit ("GSO") is provided in Annex 3 hereto. Gogo below seeks any necessary waiver of Section 25.227(a)(1)(i)(B) relating to the off-axis EIRP spectral density of the Gogo antennas in directions other than along the GSO plane.

Galaxy 17: Galaxy 17 is a U.S.-licensed satellite positioned at the 91° W.L. orbital location,[5] and complete technical information regarding the satellite is therefore already on file with the Commission. Gogo seeks authority to use Galaxy 17 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and in the 11.7-12.2 GHz downlink spectrum, consistent with the Commission's ESAA Decisions and with the terms of the satellite license.

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[4] *Revisions to Parts 2 and 25 of the Commission's Rules to Govern the Use of Earth Stations Aboard Aircraft Communicating with Fixed-Satellite Service Geostationary-Orbit Space Stations Operating in the 10.95-11.2 GHz, 11.45-11.7 GHz, 11.7-12.2 GHz and 14-14.5 GHz Frequency Bands*, Notice of Proposed Rulemaking and Report and Order, IB Docket Nos. 12-376 & 05-20, 27 FCC Rcd 16510 (2012) ("ESAA Order"); Second Report and Order and Order on Reconsideration, IB Docket No. 12-376, 29 FCC Rcd 4226 (2014) ("ESAA Second Order," and with the ESAA Order, the "ESAA Decisions").

[5] *See PanAmSat License Corp.,* Call Sign S2715, File Nos. SAT-RPL-20061219-00155 & SAT-AMD-20070123-00013, grant-stamped Apr. 24, 2007.

Galaxy 17 will provide coverage of North America. A letter confirming that operation of the Gogo ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of Galaxy 17 is included in Annex 4.

Intelsat 18: Intelsat 18 is a U.S.-licensed satellite positioned at the 180° E.L. orbital location,[6] and complete technical information regarding the satellite is therefore already on file with the Commission. Gogo seeks authority to use Intelsat 18 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum, consistent with the Commission's ESAA Decisions and with the terms of the satellite license. Gogo also seeks authority to use Intelsat 18 capacity for ESAA operations on a nonconforming basis in the 12.25-12.75 GHz downlink spectrum.

Intelsat 18 will provide coverage of the South Pacific. A letter confirming that operation of the Gogo ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of Intelsat 18 is included in Annex 4.

Eutelsat 115 West B: Eutelsat 115 West B (formerly known as Satmex 7) is licensed by Mexico and will be positioned at the 114.9° W.L. orbital location, replacing the capacity provided by Satmex 5. The Commission placed Eutelsat 115 West B on the Permitted Space Station List for operations at this location in the conventional Ku-band,[7] and complete technical information regarding the satellite is therefore already on file with the Commission. Gogo seeks authority to use Eutelsat 115 West B capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and the 11.7-12.2 GHz downlink spectrum, consistent with the Commission's ESAA Decisions and the satellite's authorization.

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[6] *See Intelsat License LLC*, Call Sign S2817, File No. SAT-LOA-20101014-00219, grant-stamped July 26, 2011.

[7] *See Satelites Mexicanos S.A. de C.V.*, Call Sign S2938, File No. SAT-PPL-20150227-00008, grant-stamped June 11, 2015.

Eutelsat 115 West B will provide coverage of North America. A letter confirming that operation of the Gogo ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of Eutelsat 115 West B is included in Annex 4.

Eutelsat 117 West A: Eutelsat 117 West A (formerly known as Satmex 8) is licensed by Mexico and is positioned at the 116.8° W.L. orbital location. The Commission placed Eutelsat 117 West A on the Permitted Space Station List for operations at this location in the conventional Ku-band,[8] and complete technical information regarding the satellite is therefore already on file with the Commission. Gogo seeks authority to use Eutelsat 117 West A capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and the 11.7-12.2 GHz downlink spectrum, consistent with the Commission's ESAA Decisions and the satellite's authorization.

Eutelsat 117 West A will provide coverage of Central and South America. A letter confirming that operation of the Gogo ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of Eutelsat 117 West A is included in Annex 4.

JCSAT-2B: JCSAT-2B (formerly referred to JCSAT-14) is licensed by Japan and is scheduled to be launched in the first quarter of 2016 into the 154° E.L. orbital location, where it will replace JCSAT-2A. JCSAT-2B is not on the Permitted Space Station List, but its licensing administration, Japan, is a member of the World Trade Organization ("WTO"). Accordingly, under the Commission's *DISCO II* market access framework, there is a presumption that allowing the satellite to communicate with U.S.-licensed earth stations for

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8 *See Satelites Mexicanos S.A. de C.V.*, Call Sign S2871, File No. SAT-PPL-20120823-00140, grant-stamped Dec. 6, 2012.

services covered by the WTO Basic Telecommunications Agreement will serve the public interest.[9]

Gogo seeks authority to use JCSAT-2B capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and on an unprotected basis in the 11.45-11.7 GHz downlink spectrum, consistent with the Commission's ESAA Decisions. Gogo also seeks authority to use JCSAT-2B capacity for ESAA operations on a nonconforming basis in the 12.25-12.75 GHz downlink spectrum.

JCSAT-2B will provide coverage of the South Pacific. A letter confirming that operation of the Gogo ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of JCSAT-2B is included in Annex 4. In addition, Annex 5 contains technical materials regarding the proposed Gogo operations with JCSAT-2B, including a coverage map, link budgets, and an orbital debris mitigation statement.

JCSAT-5A: JCSAT-5A is licensed by Japan and is positioned at the 132° E.L. orbital location. JCSAT-5A is not on the Permitted Space Station List, but the satellite has been authorized to serve the U.S. using C-band frequencies.[10] Moreover, Japan, the licensing administration for JCSAT-5A, is a member of the WTO. Accordingly, under the Commission's *DISCO II* market access framework referenced above, there is a presumption that allowing the satellite to communicate with U.S.-licensed earth stations for services covered by the WTO Basic Telecommunications Agreement will serve the public interest.

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9 *See Amendment of the Commission's Policies to Allow Non-U.S. Licensed Space Stations providing Domestic and International Service in the United States*, Report & Order, 12 FCC Rcd 24094, 24112, ¶ 39 (1997) ("*DISCO II*").

10 *See Hawaii Pacific Teleport, L.P.*, Call Sign E010016, File No. SES-MFS-20061109-01976, granted Mar. 7, 2007.

Gogo seeks authority to use JCSAT-5A capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum, consistent with the Commission's ESAA Decisions. Gogo also seeks authority to use JCSAT-5A capacity for ESAA operations on a nonconforming basis in the 12.25-12.75 GHz downlink spectrum. JCSAT-5A will be used only for communications with the Aerosat antenna system.

JCSAT-5A will provide coverage of Japan. A letter confirming that operation of the Gogo ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of JCSAT-5A is included in Annex 4. In addition, to supplement the technical information in the Commission's files regarding this spacecraft, Gogo is including in Annex 5 to this application a Ku-band coverage map, Ku-band link budgets, and a current orbital debris mitigation statement for JCSAT-5A.

Yamal 300K: Yamal 300K is licensed by Russia and is positioned at the 183° E.L. (177° W.L.) orbital location. Yamal 300K is not on the Permitted Space Station List, but the satellite has been authorized to serve the U.S. for ESAA operations at its prior orbital position.[11] Moreover, Russia, the licensing administration for Yamal 300K, is a member of the WTO. Accordingly, under the Commission's *DISCO II* market access framework referenced above, there is a presumption that allowing the satellite to communicate with U.S.-licensed earth stations for services covered by the WTO Basic Telecommunications Agreement will serve the public interest.

Gogo seeks authority to use Yamal 300K capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and on an unprotected basis in the 10.95-11.2 GHz and 11.45-11.7 GHz downlink spectrum, consistent with the Commission's ESAA

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[11] *See Panasonic Avionics Corporation*, File No. SES-MFS-20130930-00845, Call Sign E100089, granted Sept. 24, 2014 (the "Panasonic E100089 Grant").

Decisions. Gogo also seeks authority to use Yamal 300K capacity for ESAA operations on a nonconforming basis in the 12.5-12.75 GHz downlink spectrum.

Yamal 300K will provide coverage of the North Pacific Ocean. A letter confirming that operation of the Gogo ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of Yamal 300K is included in Annex 4. In addition, Annex 5 contains technical materials regarding the proposed Gogo operations with Yamal 300K, including a coverage map, link budgets, and an updated orbital debris mitigation statement.

Yamal 401: Yamal 401 is licensed by Russia and is positioned at the 90° E.L. orbital location. Yamal 401 is not on the Permitted Space Station List, but its licensing administration, Russia, is a member of the WTO. Accordingly, under the Commission's *DISCO II* market access framework referenced above, there is a presumption that allowing the satellite to communicate with U.S.-licensed earth stations for services covered by the WTO Basic Telecommunications Agreement will serve the public interest.

Gogo seeks authority to use Yamal 401 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum and on an unprotected basis in the 10.95-11.2 GHz and 11.45-11.7 GHz downlink spectrum, consistent with the Commission's ESAA Decisions. Gogo also seeks authority to use Yamal 401 capacity for ESAA operations on a nonconforming basis in the 12.5-12.75 GHz downlink spectrum.

Yamal 401 will provide coverage of Russia. A letter confirming that operation of the Gogo ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of Yamal 401 is included in Annex 4. In addition, Annex 5 contains technical materials regarding the proposed Gogo operations with Yamal 401, including a coverage map, link budgets, and an orbital debris mitigation statement.

AsiaSat 7: AsiaSat 7 is licensed by China and is positioned at the 105.5° E.L. orbital location. AsiaSat 7 is not on the Permitted Space Station List, but its licensing administration, China, is a member of the WTO. Accordingly, under the Commission's *DISCO II* market access framework referenced above, there is a presumption that allowing the satellite to communicate with U.S.-licensed earth stations for services covered by the WTO Basic Telecommunications Agreement will serve the public interest.

Gogo seeks authority to use AsiaSat 7 capacity for ESAA operations on a primary basis in the 14-14.5 GHz uplink spectrum, consistent with the Commission's ESAA Decisions. Gogo also seeks authority to use AsiaSat 7 capacity for ESAA operations on a nonconforming basis in the 12.25-12.75 GHz downlink spectrum.

AsiaSat 7 will provide coverage of China. A letter confirming that operation of the Gogo ESAA terminals is consistent with coordination agreements with satellites operated within six degrees of AsiaSat 7 is included in Annex 4. In addition, Annex 5 contains technical materials regarding the proposed Gogo operations with AsiaSat 7, including a coverage map, link budgets, and an orbital debris mitigation statement.

II. COORDINATION AND SPECTRUM SHARING MATTERS

Attached as Annex 4 pursuant to Section 25.227(b)(2) of the Commission's rules are copies of letters confirming that Gogo's proposed ESAA operations are consistent with the coordination agreements between the satellites discussed above and operators of adjacent spacecraft. Furthermore, Gogo's operations with the additional satellites will conform to the terms of Gogo's agreements with the National Aeronautics and Space Administration and the National Science Foundation, as required by the Gogo ESAA License.[12]

III. WAIVER REQUESTS

Gogo seeks limited waivers of the Commission's rules in connection with its request to add satellites as authorized points of communication for the Gogo ESAA network. Specifically, Gogo seeks a waiver of the Table of Allocations for its proposed operations in the 12.25-12.75 GHz spectrum; a waiver of orbital debris mitigation requirements for satellites that cannot fully vent propellants and/or relieve pressure vessels at end of life; and a waiver of the requirements of Section 25.227(a)(1)(i)(B) regarding the off-axis EIRP spectral density emitted by the Gogo antennas communicating with AMC-1 in directions other than along the GSO plane. Grant of these waivers is consistent with Commission policy:

> The Commission may waive a rule for good cause shown. Waiver is appropriate if special circumstances warrant a deviation from the general rule and such deviation would better serve the public interest than would strict adherence to the general rule. Generally, the Commission may grant a waiver of its rules in a particular case if the relief requested would not undermine the policy objective of the rule in question and would otherwise serve the public interest.[13]

<u>*Section 2.106*</u>: Gogo requests waiver of the Table of Allocations in Section 2.106 of the Commission's rules to permit use of downlink spectrum in the 12.25-12.75 GHz band range for ESAA operations. Gogo proposes to use capacity in part or all of this spectrum range on the following spacecraft: Intelsat 18; JCSAT-2B; JCSAT-5A; Yamal 300K; Yamal 401; and AsiaSat 7.

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[12] Gogo ESAA License, Special and General Provisions, Condition 90057.

[13] *PanAmSat Licensee Corp.*, 17 FCC Rcd 10483, 10492 (Sat. Div. 2002) (footnotes omitted).

Prior to adoption of the ESAA decisions, the Commission granted waivers for downlink operations in the 11.7-12.2 GHz conventional Ku-band downlink spectrum "based upon either a showing that the proposed AMSS downlink transmissions will not exceed the 10 dBW/4 kHz limit for routine processing in Section 25.134(g)(2) of the Commission's rules or proof that adjacent satellite operators have consented to the operations."[14] ESAA operators were also permitted to use extended Ku-band frequencies for ESAA downlinks pursuant to the same rationale.[15] The Commission has recognized that "terminals on U.S.-registered aircraft may need to access foreign satellites while traveling outside of the United States (*e.g.*, over international waters), and therefore may need to downlink in the extended Ku-band in certain circumstances."[16]

The Commission's ESAA Decisions modified the Table of Allocations to permit ESAA operations in the conventional Ku-band, as well as in the 10.95-11.2 GHz and 11.45-11.7 GHz segments of the extended Ku-band. The Commission acknowledged that ESAA operators may also wish to use other downlink spectrum, particularly for reception of transmissions from space stations with little or no U.S. coverage.[17] Although the Commission had not requested comment on changing the allocation status of this downlink spectrum, it

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[14] *See, e.g., Panasonic Avionics Corporation, Application for Authority to Operate Up to 50 Technically Identical Aeronautical Mobile-Satellite Service Aircraft Earth Stations in the 14.0-14.4 GHz and 11.7-12.2 GHz Frequency Bands,* Order and Authorization, 26 FCC Rcd 12557 (IB and OET 2011) at ¶ 11.

[15] *See* Row 44 Inc., File No. SES-MFS-20100715-00903, Call Sign E080100, Attachment at 3 (requesting expansion of the waiver of Section 2.106 that Row 44 was granted for conventional Ku-band downlinks to cover the proposed use of the 11.45-11.7 GHz band), granted Dec. 23, 2010.

[16] *Service Rules and Procedures to Govern the Use of Aeronautical Mobile Satellite Service Earth Stations in Frequency Bands Allocated to the Fixed Satellite Service,* IB Docket No. 05-20, Notice of Proposed Rulemaking, 20 FCC Rcd 2906 (2005) at ¶ 18 (footnote omitted).

[17] *See ESAA Order* at n.43.

specifically contemplated that access to such spectrum could be granted "on a case-by-case basis under Part 25 licensing rules."[18] For example, the Commission has authorized Gogo and other ESAA providers to receive signals in the 12.2-12.75 GHz band.[19]

Consistent with these past rulings, Gogo requests a waiver of the Table of Allocations to permit its terminals to receive transmissions from the Yamal 300K and Yamal 401 spacecraft in the 12.5-12.75 GHz band and from the Intelsat 18; JCSAT-2B; JCSAT-5A; and AsiaSat 7 spacecraft in the 12.25-12.75 GHz band. None of these spacecraft is proposed to be used in U.S. airspace. As noted above, the satellite operators that will provide capacity to Gogo have coordinated the ESAA operations with satellites within six degrees. Authorizing Gogo to receive signals from these satellites will not alter the technical characteristics of the satellites' operations in any way, and therefore will not create harmful interference to other authorized users of the spectrum. Furthermore, Gogo will not claim interference protection from such authorized users. Under these circumstances, grant of a Section 2.106 waiver is justified to permit use of the 12.25-12.75 GHz band for downlinks as part of the Gogo ESAA network.

Section 25.283(c): Section 25.283(c) specifies requirements relating to venting stored energy sources at the spacecraft's end of life. Specifically, the rule provides that upon completion of a satellite's mission, "a space station licensee shall ensure, unless prevented by technical failures beyond its control, that all stored energy sources on board the satellite are discharged, by venting excess propellant, discharging batteries, relieving pressure vessels, and

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18 *Id.*

19 *See, e.g.*, Gogo Blanket License, Section B (authorizing use of the 12.2-12.75 GHz band); *Panasonic Avionics Corporation*, File No. SES-MFS-20130930-00845, Call Sign E100089, granted Sept. 24, 2014 (the "Panasonic ESAA Grant"), Section B (authorizing use of the 10.7-12.75 GHz band).

other appropriate measures."[20] Gogo requests any necessary waiver of this requirement in connection with its request to communicate with the JCSAT-5A and Yamal 401 satellites, in-orbit spacecraft that were not designed to allow complete venting at end of life. The Commission has already determined that grant of a waiver is appropriate for the Yamal 300K satellite, which similarly was not designed to allow complete venting at end of life.[21]

JCSAT-5A is a Lockheed Martin A2100 model spacecraft. As described in more detail in the attached Orbital Debris Mitigation Statement, the oxidizer tanks on the JCSAT-5A spacecraft were sealed following completion of the launch phase and will therefore retain residual pressure when the spacecraft is retired. Given the spacecraft design, it is physically impossible to vent the oxidizer tanks in order to comply with Section 25.283(c).

Yamal 401 is an ISS Reshetnev Ekspress-2000 model spacecraft. As described in more detail in the attached Orbital Debris Mitigation Statement, the satellite will retain a small residual amount of nitrogen and xenon at end of life.

Under Commission precedent, grant of a waiver is warranted. In a number of cases involving various spacecraft models with similar limitations, the Commission has waived Section 25.283(c) to permit launch and operation of spacecraft that do not allow for full venting of pressure vessels at end of life, based on a finding that modifying the space station design at a late stage of construction would pose an undue hardship.[22] In the case of the JCSAT-5A and

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[20] 47 C.F.R. § 25.283(c).

[21] *See* Panasonic E100089 Grant, Special and General Provisions, Condition 90169.

[22] *See, e.g., EchoStar Satellite Operating Corp.*, File No. SAT-LOA-20071221-00183, Call Sign S2746, grant-stamped Mar. 12, 2008, Attachment at ¶ 4 (granting a partial waiver of Section 25.283(c) for AMC-14, a Lockheed Martin A2100 model spacecraft, on grounds that requiring modification of satellite would present an undue hardship); *DIRECTV Enterprises LLC*, File No. SAT-LOA-20090807-00086, Call Sign S2797, grant-stamped Dec. 15, 2009, Attachment at ¶ 4 (same for DIRECTV 12, a Boeing 702 model spacecraft); *PanAmSat Licensee Corp.*, File Nos. SAT-MOD-20070207-00027, SAT-AMD-20070716-00102, Call Sign S2237,

Yamal 401 satellites, which are currently in-orbit, there is no question of bringing the satellites into compliance with the rule. The Commission has expressly recognized this, finding a waiver of Section 25.283(c) to be justified for in-orbit spacecraft that cannot satisfy the rule's requirements. For example, in a decision involving the AMC-2 satellite, which is a Lockheed Martin A2100 design like JCSAT-5A, the Commission waived Section 25.283(c) on its own motion, observing that venting the spacecraft's sealed oxidizer tanks "would require direct retrieval of the satellite, which is not currently possible."[23] Similarly, as noted above the Commission has authorized the use of the Yamal 300K satellite, an ISS Reshetnev Ekspress spacecraft, for ESAA operations pursuant to a waiver of Section 25.283(c) because requiring compliance with the rule would result in "undue hardship."[24]

The same practical obstacle is present here. Because JCSAT-5A and Yamal 401 are already in orbit, they cannot be modified to enable full venting of residual pressure. Given this reality, a waiver is clearly warranted.

__Section 25.227(a)(1)(i)(B)__: Gogo also seeks any necessary waiver of Section 25.227(a)(1)(i)(B) in connection with the off-axis EIRP spectral density emitted by the Gogo antennas communicating with AMC-1 in directions other than along the GSO plane. This provision was intended to prevent interference to Ku-band non-geostationary satellite orbit ("NGSO") systems in the Ku-band. However, no such NGSO systems are currently licensed or

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grant-stamped Oct. 4, 2007, Attachment at ¶ 7 (same for Intelsat 11, an Orbital Sciences Star model spacecraft).

23 File No. SAT-MOD-20101215-00261, Call Sign S2134, grant-stamped Mar. 8, 2011, Attachment at ¶ 4. *See also XM Radio Inc.*, File No. SAT-MOD-20100722-00165, Call Sign S2616, grant-stamped Oct. 14, 2010, Attachment at ¶ 2 (waiving Section 25.283(c) for XM-4, a Boeing 702 model spacecraft, because "modification of the spacecraft would present an undue hardship, since XM-4 is an in-orbit space station and venting XM-4's helium and xenon tanks would require direct retrieval of the satellite, which is not currently possible").

24 *See* Panasonic E100089 Grant, Special and General Provisions, Condition 90169.

operating. In the event a future NGSO network is deployed, Gogo will coordinate with the new network as required in order to facilitate co-frequency operations.

Grant of a rule waiver under these circumstances is consistent with Commission precedent. In particular, the Commission has authorized other types of mobile applications of the fixed-satellite service in situations where the applicant did not comply with the off-axis EIRP spectral density mask in directions other than along the GSO plane.[25] The same rationale supports grant of a waiver to facilitate the ESAA operations proposed by Gogo.

IV. CONCLUSION

Gogo respectfully requests that the Commission modify the Gogo ESAA License to reflect the changes described herein.

Respectfully submitted,

GOGO LLC

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[25] *See, e.g., ThinKom Solutions Inc.,* File No. SES-LIC-20120822-00768, Call Sign E120174, granted March 8, 2013 (grant of vehicle-mounted earth station authority for antenna that did not meet the applicable off-axis EIRP spectral density mask in directions other than along the GSO plane).

ANNEX 1:

Table of Information Required by Section 25.227

Section 25.227 Requirement	**Citation to Information Provided**
25.227(a)(1)(ii) & 25.227(a)(1)(iii)	Gogo has previously demonstrated that each of its ESAA antennas will maintain a pointing error of less than or equal to 0.2° between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna and will automatically cease transmission within 100 milliseconds if the angle between the orbital location of the target satellite and the axis of the main lobe of the ESAA antenna exceeds 0.5°, and transmission shall not resume until such angle is less than or equal to 0.2°. *See* File No. SES-AMD-20120731-00709, Technical Appendix, Section 2.2.4; File No. SES-MFS-20140801-00625, Technical Annex, Section 1.3.
25.227(a)(4) & 25.227(b)(5)	N/A: Gogo does not propose to use a contention protocol.
25.227(a)(5) & 25.227(b)(6)	Gogo is updating the information regarding its 24/7 point of contact. The phone number remains the same, +1 866-943-4662 and the e-mail address is noc@gogoair.com. The updated street address is: Gogo Network Operations Center, 111 North Canal Street, Chicago, IL, 60606, as specified in Form 312 Schedule B, Items E2-E9.
25.227(a)(15)	Gogo certifications are in Annex 6 attached.
25.227(b)(2)(i), (ii) & (iii)	Target satellite operator certifications are in Annex 4 attached.
25.227(b)(2)(iv)	No change to prior demonstrations regarding compliance with coordination agreements and ceasing emissions.
25.227(b)(4)	Gogo's ESAA network will operate in U.S. airspace, foreign airspace, and in the airspace over international waters. Coverage areas for the specific satellites to be used in the Gogo network are described in the table found in Annex 2 attached. Contours for the AMC-1; Galaxy 17; Intelsat 18; Eutelsat 115 West B; and Eutelsat 117 West A satellites are already on file with the Commission. Coverage maps for the JCSAT-2B; JCSAT-5A; Yamal 300K; Yamal 401; and AsiaSat 7 satellites are included in Annex 5.
25.227(b)(7)	Gogo certifications are in Annex 6 attached.
25.227(b)(8)	No change to previously filed Radiation Hazard analyses.
25.227(c)	Gogo's coordination agreement with NASA was filed February 1, 2013 in File Nos. SES-LIC-20120619-00574 *et al*.
25.227(d)	Gogo's coordination agreement with NSF was included as Amendment Exhibit B in File No. SES-AMD-20120731-00709.

ANNEX 2:

Updated Spacecraft and Teleport Tables

Satellite	Location	Beam Coverage Area	Tx (GHz)	Rx (GHz)	Use in US airspace?	Satellite Operator
AMC-1	129.15W	North America	14-14.5	11.7-12.2	Yes	SES
SES-1	101W	North America	14-14.5	11.7–12.2	Yes	SES
SES-4	22W	Europe	14-14.5	12.5-12.75	No	SES
SES-6	40.5W	East Atlantic Ocean	14-14.5	10.95-11.2; 11.45-11.7	No	SES
SES-6	40.5W	West Atlantic Ocean	14-14.5	10.95-11.2; 11.45-11.7	Yes	SES
Galaxy 17	91W	North America	14-14.5	11.7-12.2	Yes	Intelsat
IS-18	180E	South Pacific	14-14.5	12.25-12.75	No	Intelsat
IS-14	45W	North and South America excludes Brazil	14-14.5	11.7–12.2	Yes	Intelsat
IS-21	58W	Brazil	14-14.5	11.7–12.2	No	Intelsat
IS-21	58W	South Atlantic Ocean	14-14.5	11.45–11.7	No	Intelsat
IS-22	72.1E	Mobility from Mideast to Japan and to Australia	14-14.5	12.25–12.5	No	Intelsat
IS-19	166E	Northeast Pacific	14-14.5	12.25-12.75	Yes	Intelsat
IS-19	166E	Northwest Pacific	14-14.5	12.25-12.75	No	Intelsat
IS-19	166E	Australia	14-14.5	12.25-12.75	No	Intelsat
IS-19	166E	Southwest Pacific	14-14.5	12.25-12.75	No	Intelsat
IS-904	60E	Spot 1 - Western Russia	14-14.5	10.95–11.2; 11.45-11.7	No	Intelsat
Eutelsat 115WB (Satmex 7)	114.9W	North America	14-14.5	11.7-12.2	Yes	Eutelsat
Eutelsat 117WA (Satmex 8)	116.8W	Central and South America	14-14.5	11.7-12.2	Yes	Eutelsat
E172A[1]	172E	North Pacific and Northeastern Russia	14-14.5	10.95-11.2; 11.45-11.7; 12.2-12.75	No	Eutelsat

[1] This satellite is only used for communications with the Aerosat antenna system.

Satellite	Location	Beam Coverage Area	Tx (GHz)	Rx (GHz)	Use in US airspace?	Satellite Operator
T-11N	37.5W	Africa	14-14.5	10.95-11.2; 11.45-11.7; 12.5-12.75	No	Telesat
		Atlantic	14-14.5	11.45-11.7	No	
T-18	138E	Asia	14-14.5	12.2–12.75	No	
JCSAT-2B	154E	South Pacific	14-14.5	11.45-11.7; 12.25-12.75	No	JSAT
JCSAT-5A[2]	132E	Japan	14-14.5	12.25-12.75	No	
Yamal 300K	183E (177W)	North Pacific Ocean	14-14.5	10.95-11.2; 11.45-11.7; 12.5-12.75	No	Gazprom Space Systems
Yamal 401	90E	Russia	14-14.5	10.95-11.2; 11.45-11.7; 12.5-12.75	No	
Asiasat 7	105.5E	China	14-14.5	12.25-12.75	No	AsiaSat

[2] This satellite is only used for communications with the Aerosat antenna system.

Satellite	Teleport Location	FCC Call Sign
AMC-1	Woodbine, MD	E900448
SES-1	Woodbine, MD	E920698
SES-4	Bristow, VA	E020071
	Bristow, VA	E000696
SES-6	Betzdorf, Luxembourg	N/A
Galaxy 17	Atlanta, GA ATL-K26	E990214
IS-18	Napa teleport NAP-K22	E990224
IS-14	ATL teleport ATL-C06	E940333
	ATL teleport ATL-K15	E090093
IS-21	Rio de Janeiro, Brazil	N/A
	Mobility: MTN teleport MTN-K02	E030051
IS-22	Kumsan, Korea	N/A
IS-19	Perth, Australia	N/A
	Napa teleport NAP-K31	E980460
	Napa teleport NAP-C30	E980467
IS-904	Moscow, Russia	N/A
Eutelsat 115WB (Satmex 7)	Brewster, WA	E120043
Eutelsat 117WA (Satmex 8)	Brewster, WA	E060416
E172a	Khabarovsk, Russia	N/A
T-11N	Aflenz, Austria	N/A
T-18	China (City TBD)	N/A
JCSAT-2B	Kapolei, HI	TBD
JCSAT-5A	Yokohama, Japan	N/A
Yamal 300K	Brewster, WA BRW-05C	E120043
Yamal 401	Moscow, Russia	N/A
Asiasat 7	Beijing, China	N/A

ANNEX 3:

Compliance Showing Under Section 25.227(a)(1) and (b)(1) for AMC-1 Satellite

Gogo will be using space segment on the SES AMC-1 satellite at 129.15° west longitude, using both the AeroSat (AES1) and ThinKom (AES2) terminals. Operation on AMC-1 will be compliant with the off-axis EIRP power densities as specified in Section 25.227(a)(1). Provided below are the tables specified in Section 25.227(b)(1)(i) and the associated link analyses.

Provided are the following charts:

AeroSat Terminal System:

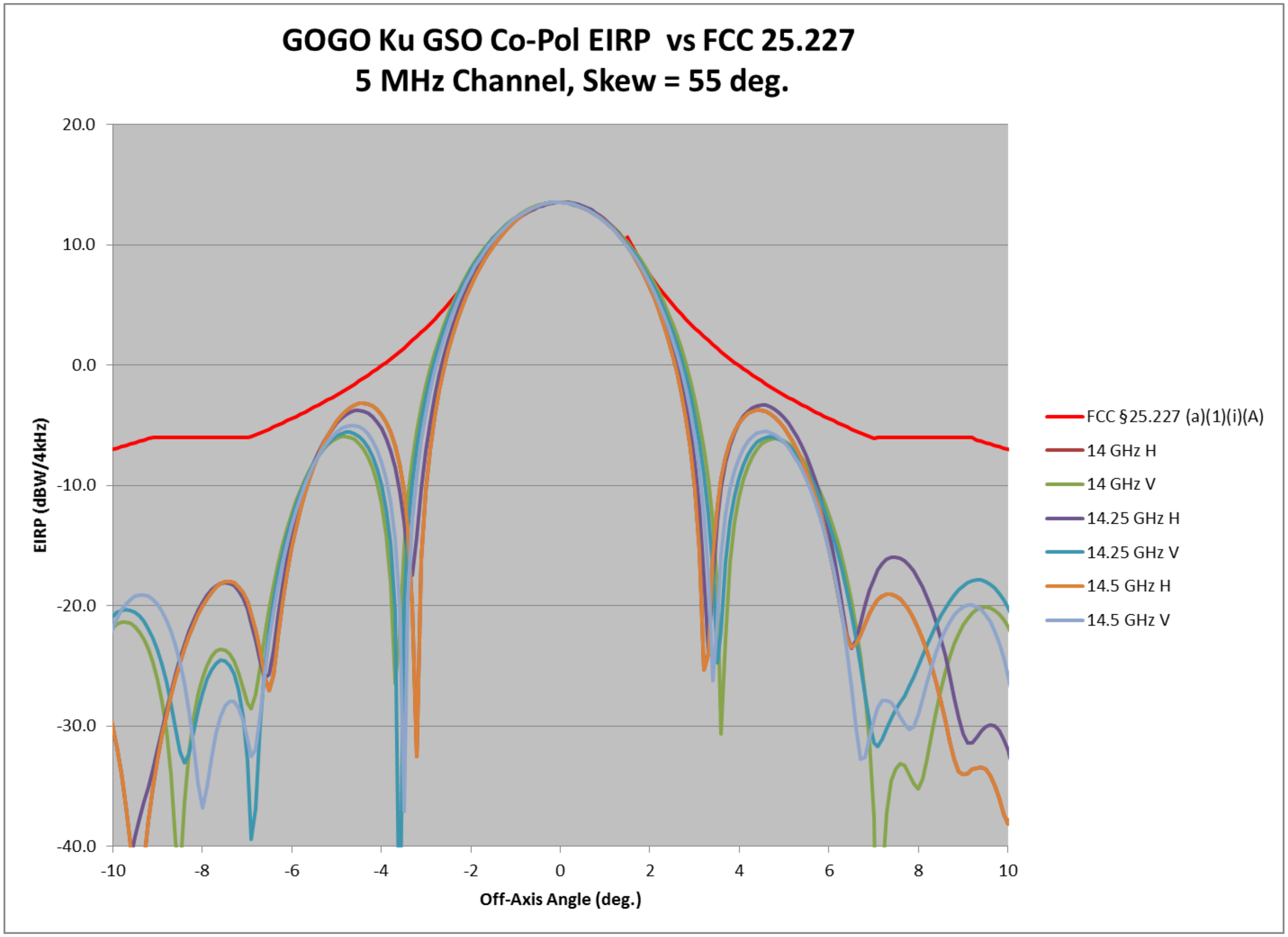
1. Co-pol GSO PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -10 to +10 degrees
2. Co-pol GSO PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -180 to +180 degrees
3. Co-pol El PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -10 to +10 degrees
4. Co-pol El PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -180 to +180 degrees
5. X-Pol PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -9.2 to +9.2 degrees
6. Link Analysis Inbound and Outbound worst case.

ThinKom Terminal System:

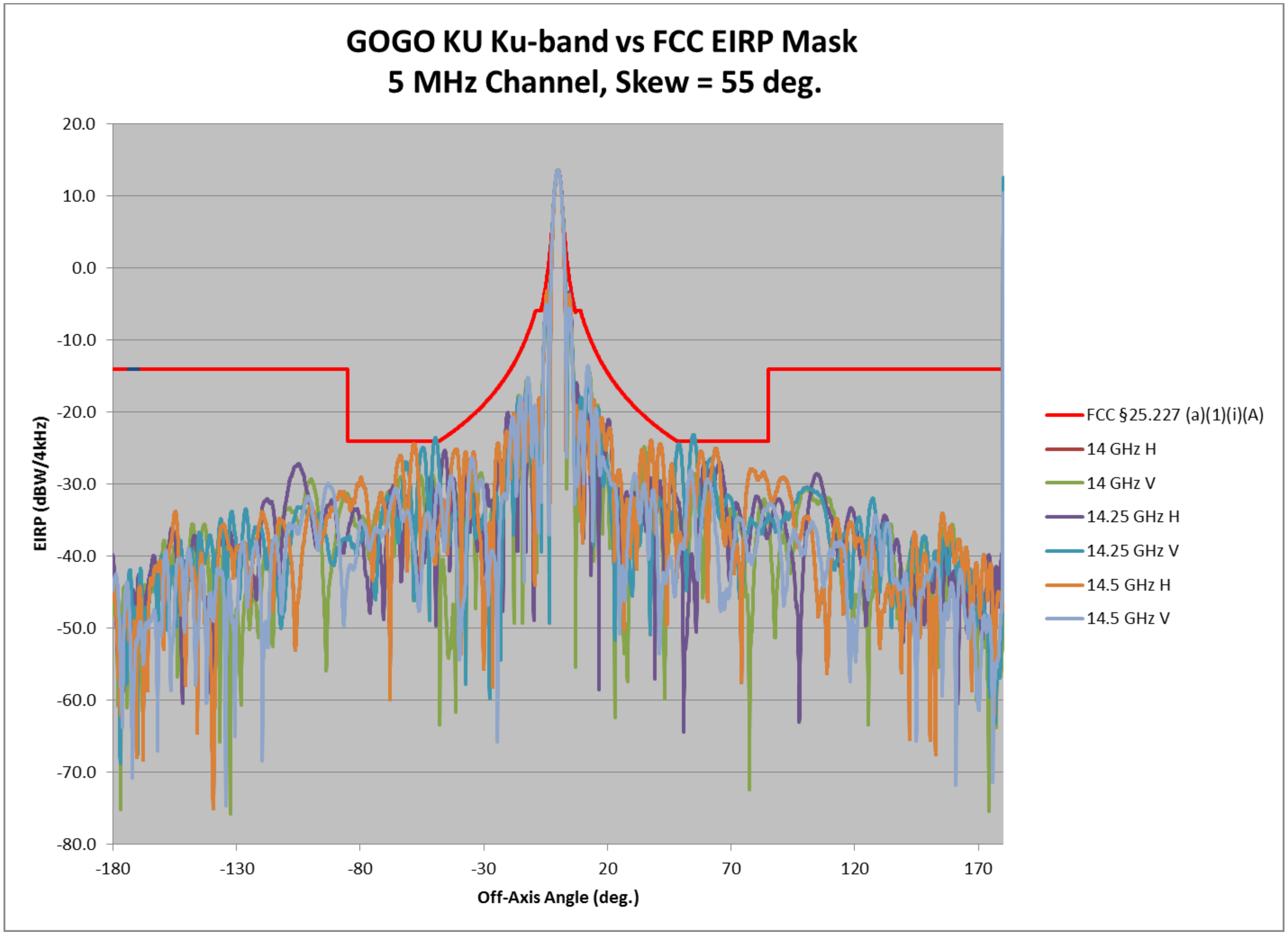
7. Co-pol GSO PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -10 to +10 degrees
8. Co-pol GSO PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -180 to +180 degrees
9. Co-pol El PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -10 to +10 degrees
10. Co-pol El PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -180 to +180 degrees
11. X-Pol PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -9.2 to +9.2 degrees
12. Link Analysis Inbound and Outbound worst case.

AeroSat Terminal System:

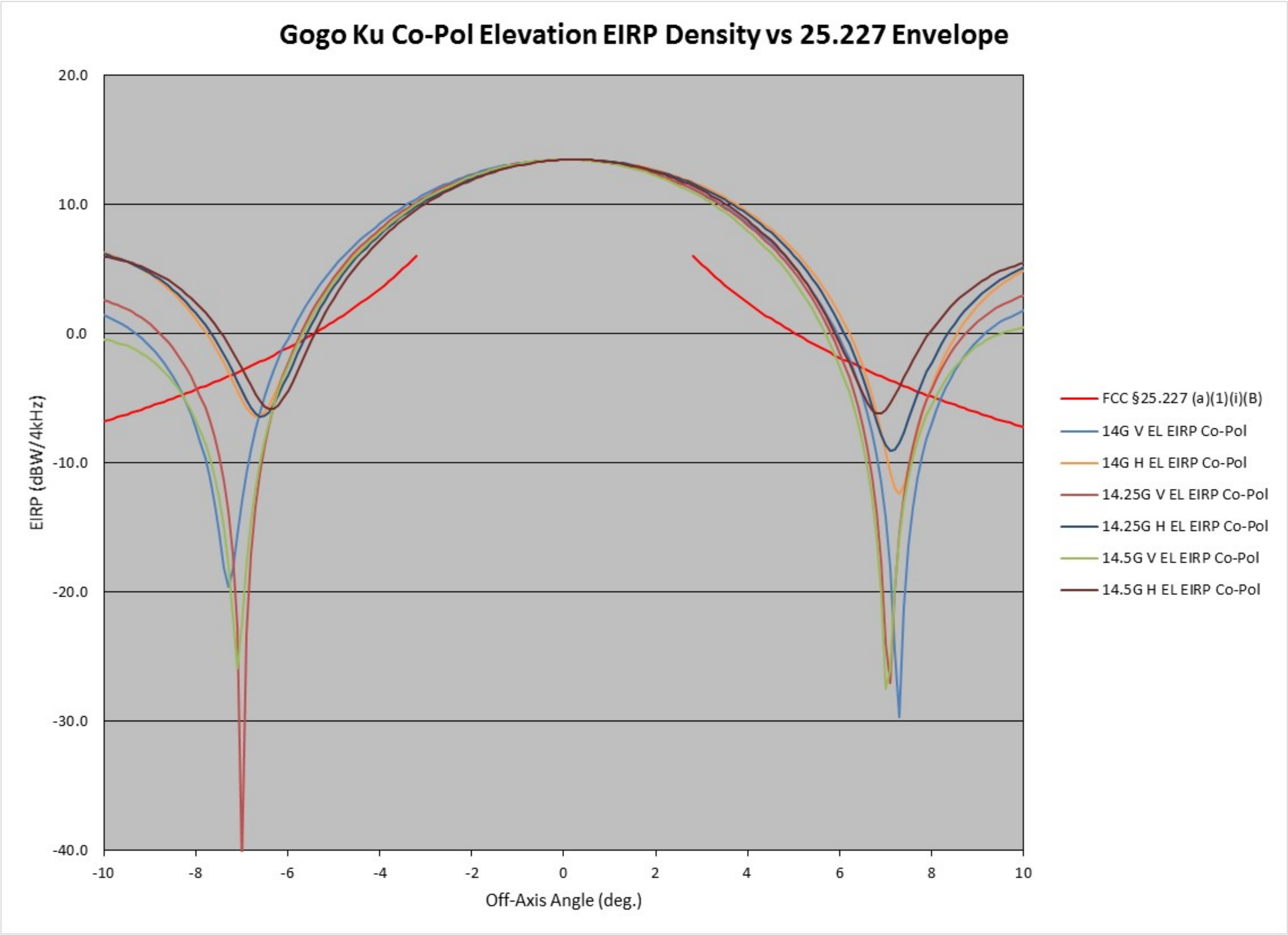
1. Co-pol GSO PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -10 to +10 degrees



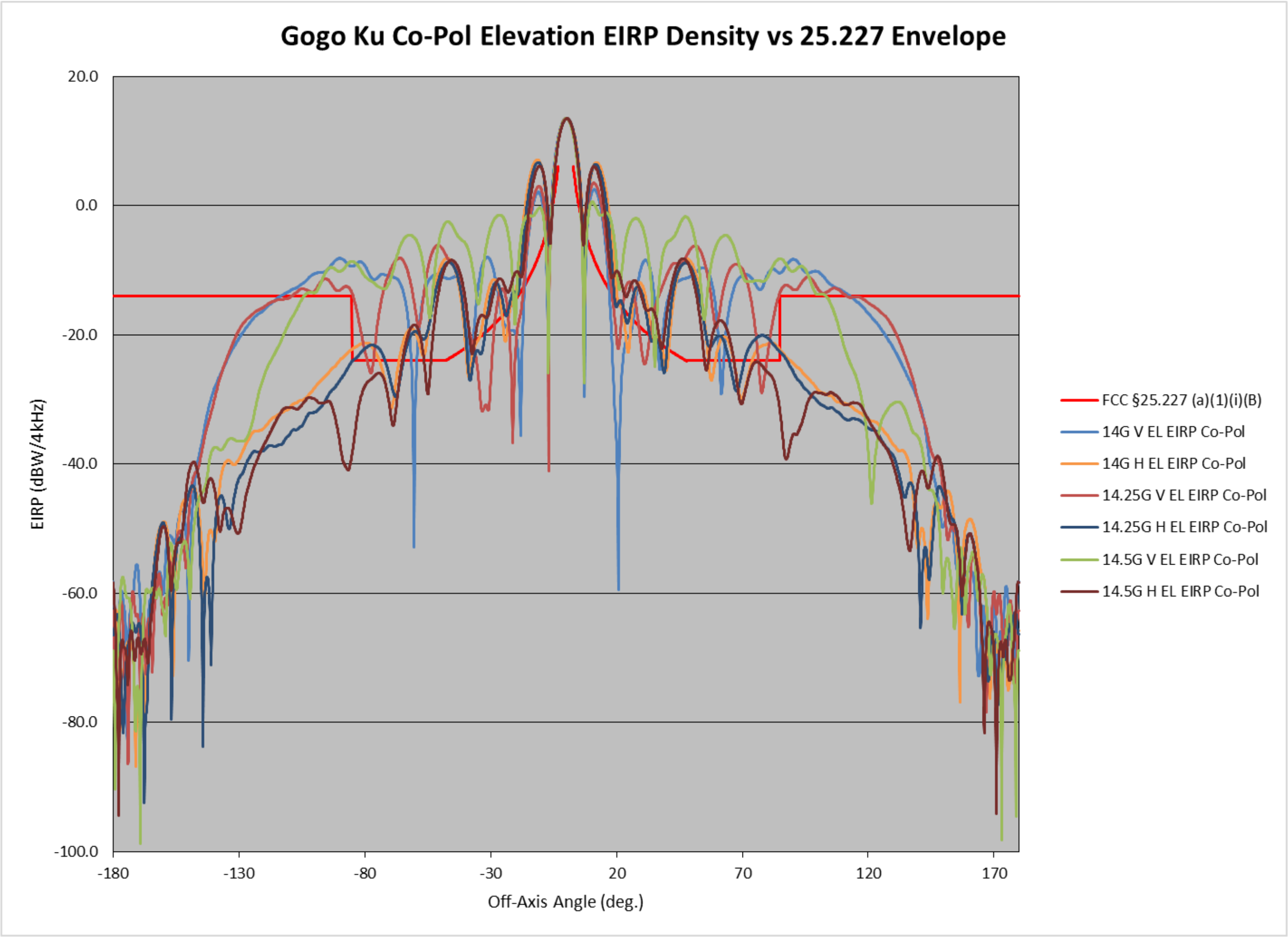
2. Co-pol GSO PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -180 to +180 degrees



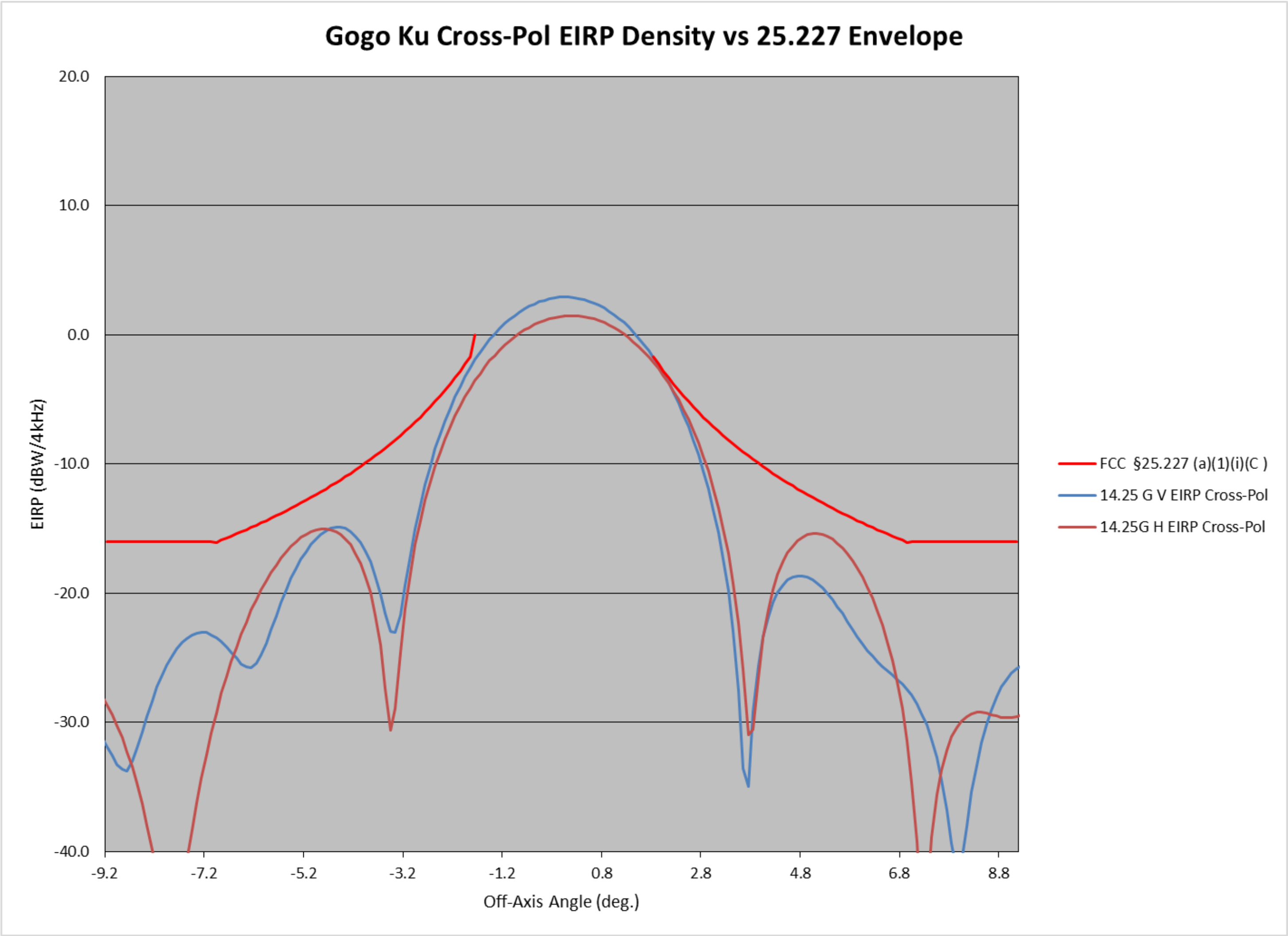
3. Co-pol El PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -10 to +10 degrees



4. Co-pol El PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -180 to +180 degrees



5. X-Pol PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -9.2 to +9.2 degrees



6. LBA for AMC-1 129.15° W.L.

AEROSAT ANTENNA

Forward Link Budget

Hub	Woodbine, MD	
Required Eb/No	1.7	dB
Modulation	QPSK	
Info Rate	30,000	Kbps
FEC Rate	1/2	
Carrier Rolloff	1.2	
Satellite SFD @ 0 dB/K	-103.0	dBW/m^2
Transponder Atten	10.0	dB
Transponder ID	US Coverage	

Hub Transmit

Frequency	14.25	GHz
Satellite G/T	5.0	dB/°K
Antenna Diameter	9.2	m
Carrier EIRP	65.7	dBW
Ant. Input PFD	-33.3	dBW/4kHz
Path Loss	207.5	dB
Atm/Point/Pol Loss	0.7	dB

Aircraft Receive Terminal

Frequency	11.95	GHz
Satellite EIRP	47.4	dBW
Downlink PFD@ Beam Center	11.2	dBW/4kHz
Receive Gain	28.05	dB
Terminal G/T	9.0	dB/°K
Path Loss	206.3	dB
Other Losses	0.6	dB

Transponder

Total OPBO	0.0	dB
Carrier OPBO	0.0	dB
C/No Thermal Up	91.1	dB-Hz
C/No Thermal Dn	77.3	dB-Hz
C/Io Total	85.5	dB-Hz
C/No+Io	76.6	dB-Hz
Add'l Link Margin	0.1	dB
% BW per cxr	99.9	%
% Power per cxr	99.0	%
Xpdr BW Alloc	36.0	MHz

Return Link Budget

Terminal	Gogo AES-1	
Required Eb/No	3.7	dB
Modulation	BPSK	
Info Rate	1250	Kbps
FEC Rate	1/2	
Carrier Spacing	1.2	
Carrier Spreading	2.0	
Satellite SFD @ 0 dB/K	-103.0	dBW/m^2
Transponder Atten	10.0	dB
Transponder ID	US Coverage	

Aircraft Transmit Terminal

Frequency	14.2	GHz
Satellite G/T	1.0	dB/°K
Antenna Diameter	0.24	m
Carrier EIRP	44.5	dBW
Ant Input PFD	-15.45	dBW/4kHz
Path Loss	207.8	dB
Atm/Point/Pol Loss	1.4	dB

Hub Receive

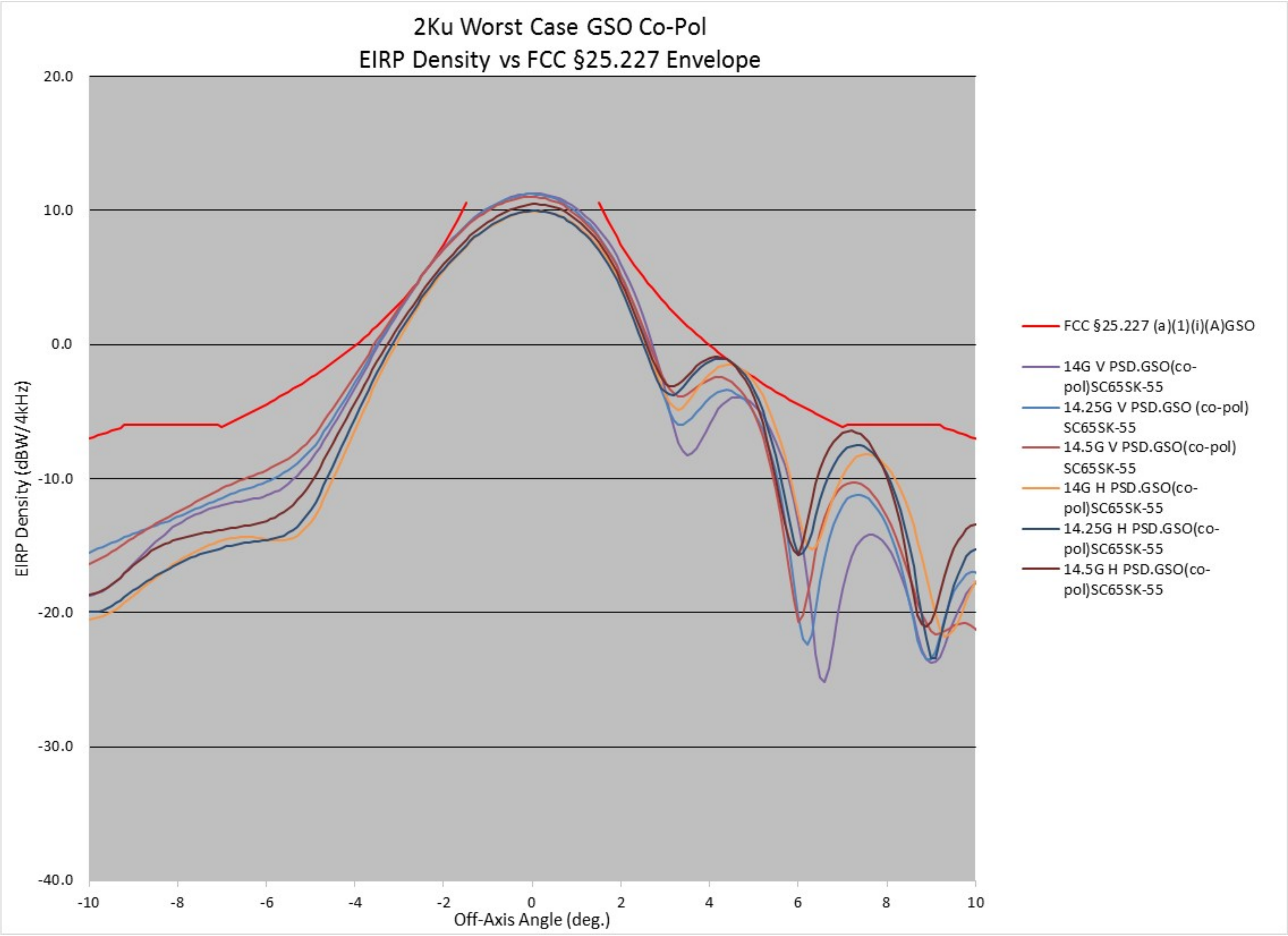
Frequency	11.9	GHz
Satellite EIRP	48.5	dBW
Downlink PFD@ Beam Center	-5.14	dBW/4kHz
Hub G/T	38.0	dB/°K
Path Loss	205.9	dB
Other Losses	0.6	dB

Transponder

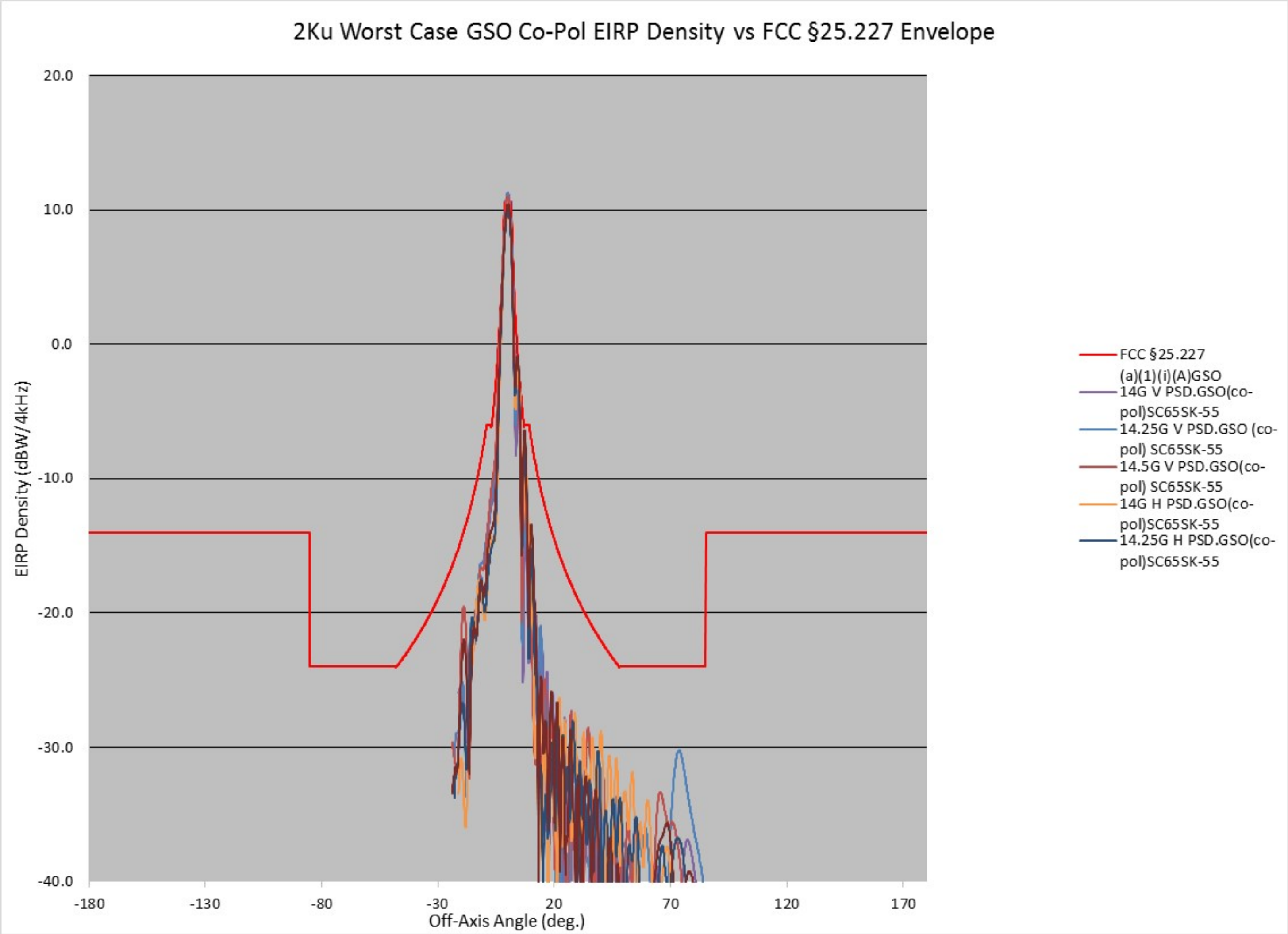
Total OPBO	4.0	dB
Carrier OPBO	24.2	dB
C/No Thermal Up	64.9	dB-Hz
C/No Thermal Dn	84.3	dB-Hz
C/Io Total	79.3	dB-Hz
C/No+Io	64.7	dB-Hz
Add'l Link Margin	0.0	dB
% BW per cxr	16.7	%
% Power per cxr	0.96	%
Xpdr BW Alloc	6.0	MHz

ThinKom Terminal System:

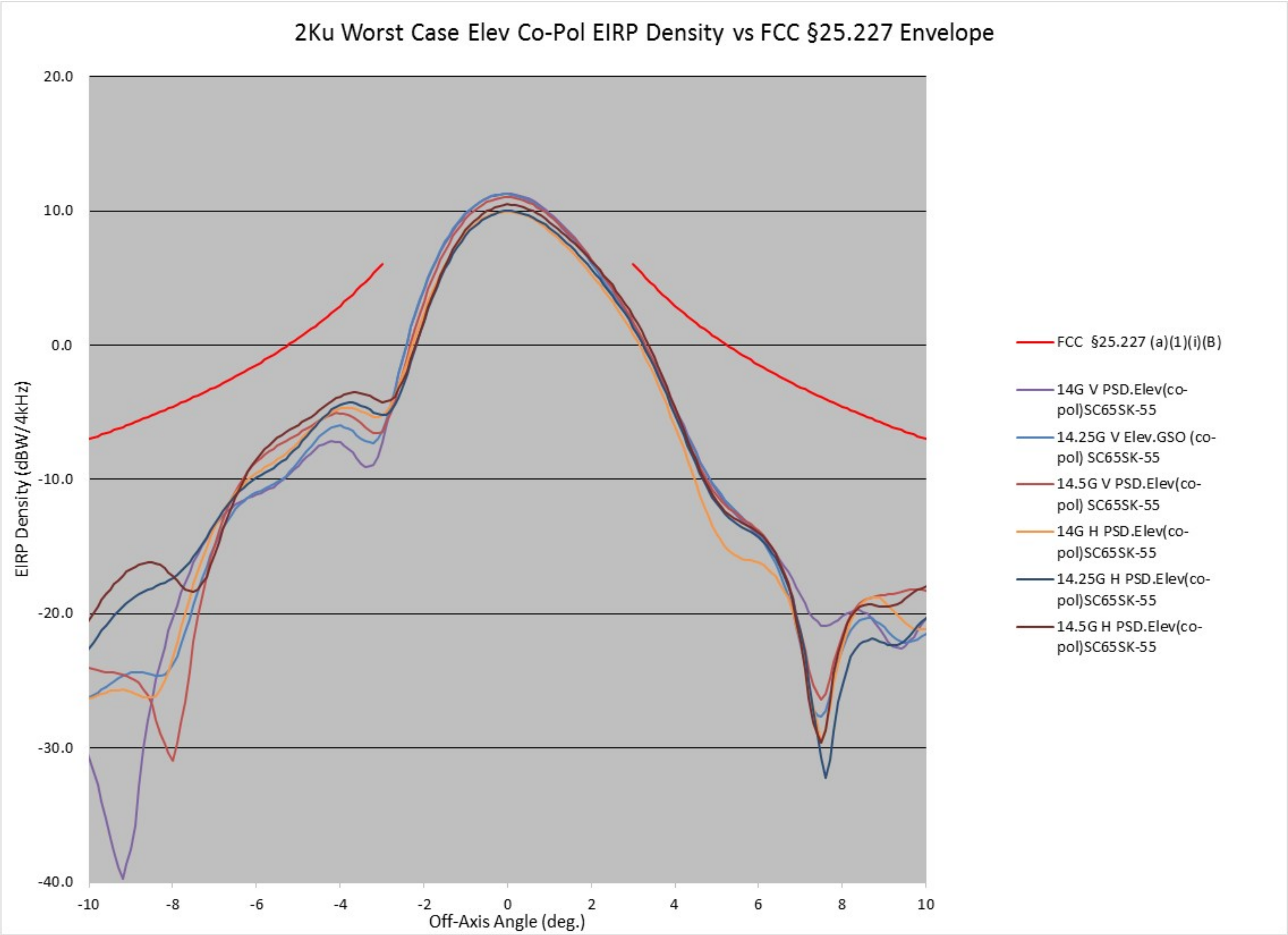
7. Co-pol GSO PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -10 to +10 degrees



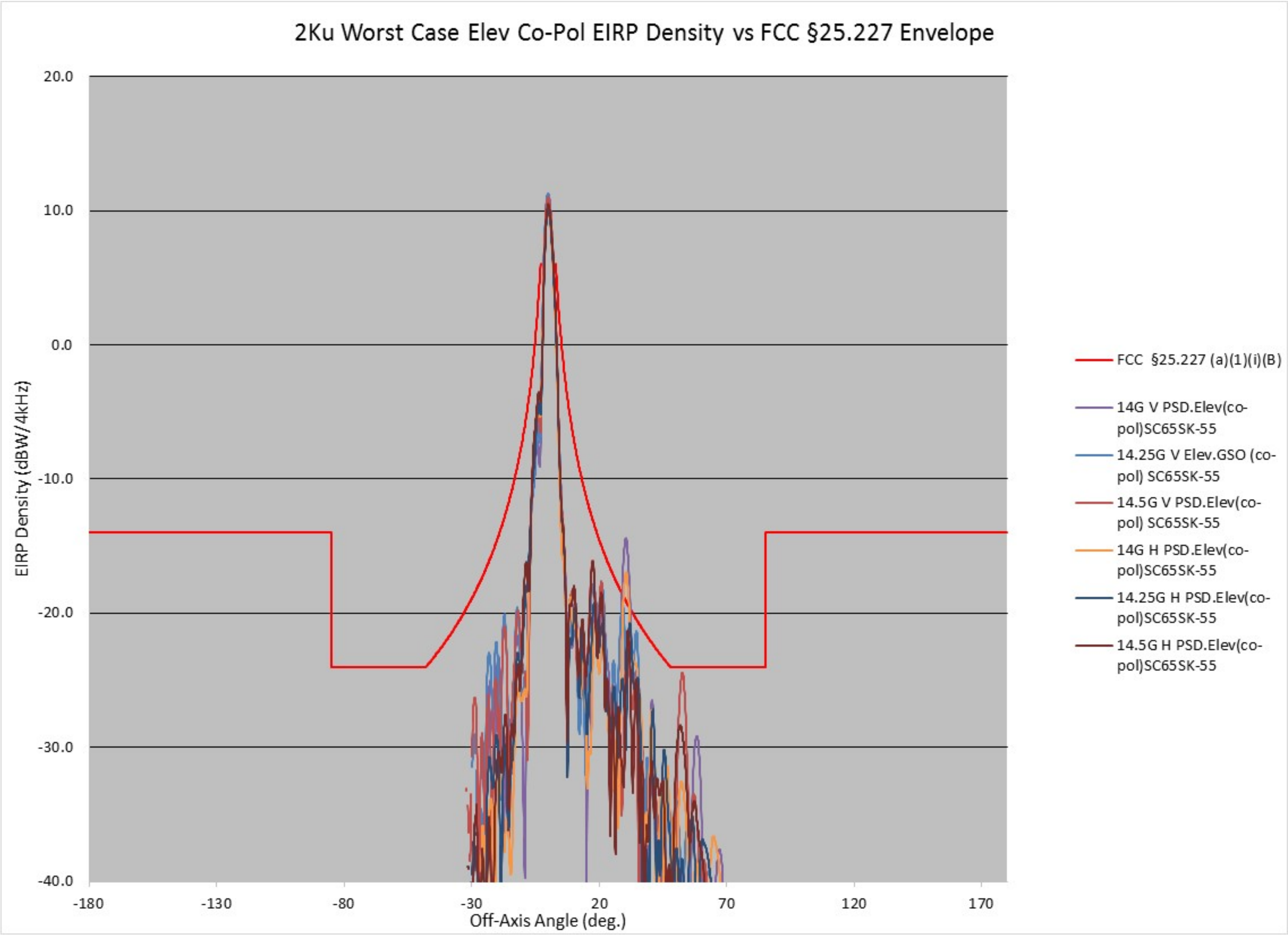
8. Co-pol GSO PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -180 to +180 degrees



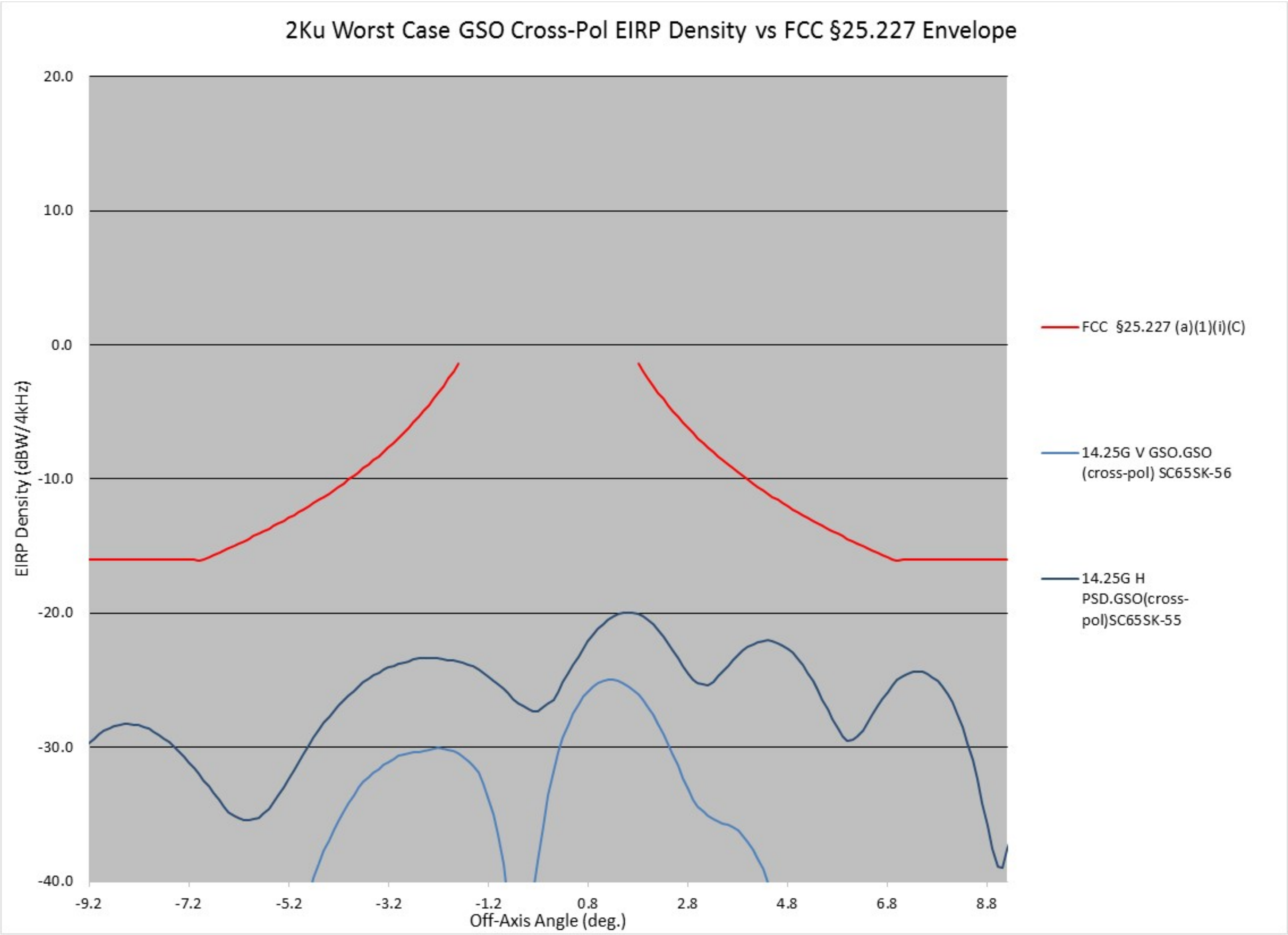
9. Co-pol El PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -10 to +10 degrees



10. Co-pol El PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -180 to +180 degrees



11. X-Pol PSD worst case Scan65 Skew-55 for 14.0 GHz, 14.25 GHz, and 14.5 GHz , -9.2 to +9.2 degrees



12. LBA for AMC-1 129 W.L.

THINKOM ANTENNA

Forward Link Budget

Hub	Woodbine, MD	
Required Eb/No	1.7	dB
Modulation	QPSK	
Info Rate	30,000	Kbps
FEC Rate	1/2	
Carrier Rolloff	1.2	
Satellite SFD @ 0 dB/K	-103.0	dBW/m^2
Transponder Atten	10.0	dB
Transponder ID	US Coverage	
Hub Transmit		
Frequency	14.25	GHz
Satellite G/T	5.0	$dB/^oK$
Antenna Diameter	9.2	m
Carrier EIRP	65.7	dBW
Ant. Input PFD	-33.3	dBW/4kHz
Path Loss	207.5	dB
Atm/Point/Pol Loss	0.7	dB
Aircraft Receive Terminal		
Frequency	11.95	GHz
Satellite EIRP	45.5	dBW
Downlink PFD@ Beam Center	11.2	dBW/4kHz
Receive Gain	30.5	dB
Terminal G/T	13.4	$dB/^oK$
Path Loss	205.9	dB
Other Losses	0.6	dB
Transponder		
Total OPBO	0.0	dB
Carrier OPBO	0.0	dB
C/No Thermal Up	91.1	dB-Hz
C/No Thermal Dn	80.9	dB-Hz
C/Io Total	85.8	dB-Hz
C/No+Io	79.4	dB-Hz
Add'l Link Margin	2.91	dB
% BW per cxr	99.9	%
% Power per cxr	99.0	%
Xpdr BW Alloc	36.0	MHz

Return Link Budget

Terminal	Gogo AES-2	
Required Eb/No	3.6	dB
Modulation	BPSK	
Info Rate	1250	Kbps
FEC Rate	2/3	
Carrier Spacing	1.30	
Carrier Spreading	4.0	
Satellite SFD @ 0 dB/K	-103.0	dBW/m^2
Transponder Atten	10.0	dB
Transponder ID	US Coverage	
Aircraft Transmit Terminal		
Frequency	14.2	GHz
Satellite G/T	1.0	$dB/^oK$
Antenna Diameter	0.74	m
Carrier EIRP	43.87	dBW
Ant Input PFD	-20.0	dBW/4kHz
Path Loss	207.4	dB
Atm/Point/Pol Loss	0.7	dB
Hub Receive		
Frequency	11.9	GHz
Satellite EIRP	48.5	dBW
Downlink PFD@ Beam Center	-5.5	dBW/4kHz
Hub G/T	38.0	$dB/^oK$
Path Loss	205.9	dB
Other Losses	0.6	dB
Transponder		
Total OPBO	4.0	dB
Carrier OPBO	22.8	dB
C/No Thermal Up	65.3	dB-Hz
C/No Thermal Dn	85.6	dB-Hz
C/Io Total	76.0	dB-Hz
C/No+Io	64.9	dB-Hz
Add'l Link Margin	0.3	dB
% BW per cxr	25.0	%
% Power per cxr	1.32	%
Xpdr BW Alloc	9.0	MHz

ANNEX 4:

Satellite Company Letters

October 7, 2015

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

Re: Engineering Certification of Intelsat for G-17 Satellite

To Whom It May Concern:

This letter confirms that Intelsat is aware that Gogo LLC ("Gogo") is planning to seek a modification to its blanket authorization (the "Modification Application") from the Federal Communications Commission ("FCC") to operate two types of Ku band transmit/receive earth stations aboard aircraft ("ESAAs"), Call Sign E120106. Among other changes, the Modification Application will seek authority for Gogo's ESAA terminals to communicate with the Galaxy-17 satellite at 91° WL. under the current ESAA rules including Section 25.227.

Based upon the representations made to Intelsat by Gogo concerning the contents of its Modification Application:

- INTELSAT acknowledges that the proposed operation of the Gogo ESAA terminals has the potential to create harmful interference to satellite networks adjacent to Galaxy-17 that may be unacceptable.
- Intelsat certifies that the proposed use of the ESAA transmit/receive terminals at the power density levels specified by Gogo are consistent with existing coordination agreements to which INTELSAT is a party with all adjacent satellite operators within +/- 6 degrees of orbital separation from Galaxy-17.
- If the FCC authorizes the operations proposed by Gogo, Intelsat will include the power density levels specified by Gogo in all future satellite network coordination with other operators of satellites adjacent to Galaxy-17.

Sincerely,

Armand Kadrichu
Senior Technical Advisor, Spectrum Strategy
INTELSAT
7900 Tysons One Place, McLean, VA 22102-5972
T +1 703-559-7525 M +1 202-445-4377
armand.kadrichu@intelsat.com

INTELSAT
Envision. Connect. Transform.

October 6, 2015

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

Re: Engineering Certification of Intelsat for IS-18 Satellite

To Whom It May Concern:

This letter confirms that Intelsat is aware that Gogo LLC ("Gogo") is planning to seek a modification to its blanket authorization (the "Modification Application") from the Federal Communications Commission ("FCC") to operate two types of Ku band transmit/receive earth stations aboard aircraft ("ESAAs"), Call Sign E120106. Among other changes, the Modification Application will seek authority for Gogo's ESAA terminals to communicate with the Intelsat-18 satellite at 180° EL. under the current ESAA rules including Section 25.227.

Based upon the representations made to Intelsat by Gogo concerning the contents of its Modification Application:

- INTELSAT acknowledges that the proposed operation of the Gogo ESAA terminals has the potential to create harmful interference to satellite networks adjacent to Intelsat-18 that may be unacceptable.
- Intelsat certifies that the proposed use of the ESAA transmit/receive terminals at the power density levels specified by Gogo are consistent with existing coordination agreements to which INTELSAT is a party with all adjacent satellite operators within +/- 6 degrees of orbital separation from Intelsat-18.
- If the FCC authorizes the operations proposed by Gogo, Intelsat will include the power density levels specified by Gogo in all future satellite network coordination with other operators of satellites adjacent to Intelsat-18.

Sincerely,

Armand Kadrichu
Senior Technical Advisor, Spectrum Strategy
INTELSAT
7900 Tysons One Place, McLean, VA 22102-5972
T +1 703-559-7525 M +1 202-445-4377
armand.kadrichu@intelsat.com

eutelsat

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

October 14, 2015

Re: Engineering Certification of Satélites Mexicanos S.A. de CV (E115WB)

To Whom It May Concern:

This letter certifies that Satelites Mexicanos S.A. de CV dba Eutelsat Americas ("EAS") has been informed by Gogo LLC ("Gogo") that it currently seeks a modification to its blanket authorization from the Federal Communications Commission ("FCC"), to operate two types of technically identical Ku-band transmit/receive earth stations aboard aircraft ("ESAAs"), Call Sign E120106. Gogo seeks additional authorization for these aeronautical Ku-band earth stations to also utilize E115WB at 114.9° W.L. under the current ESAA rules including Section 25.227.

To the extent EAS has been informed by Gogo of the plans for ESAA to the present date, EAS certifies that the proposed use of the ESAA transmit/receive terminals at the power density levels provided by EAS is consistent with existing coordination agreements with all adjacent satellite operators within +/- 6 degrees of orbital separation from E115WB. EAS also acknowledges that the proposed operation of the Gogo ESAA terminal has the potential to create and receive harmful interference from adjacent satellite networks that may be unacceptable. If the FCC authorizes the operations proposed by Gogo, EAS will take into consideration the power density levels associated with the operation of Gogo in all future satellite network coordinations with other adjacent satellite operators, in accordance with the established international regulations.

The confirmation provided by this means shall be limited to the information provided by Gogo up to the present date. Should the information of Gogo be modified, the present letter shall not be valid until further analysis is completed and if required, EAS would provide the FCC with an updated letter reflecting any modification to the above.

Sincerely,

10-14-2015
Date

Hector Fortis
Eutelsat Americas
International and Regulatory Affairs

Eutelsat Americas | Av. Paseo de la Reforma No. 222 Pisos 20 y 21 | Col. Juárez CP 06600. Mexico, D.F. |

eutelsat

Federal Communications Commission
International Bureau
445 12th Street, S. W.
Washington, D.C. 20554

October 14, 2015

Re: Engineering Certification of Satélites Mexicanos S.A. de CV (E117WA)

To Whom It May Concern:

This letter certifies that Satelites Mexicanos S.A. de CV dba Eutelsat Americas ("EAS") has been informed by Gogo LLC ("Gogo") that it currently seeks a modification to its blanket authorization from the Federal Communications Commission ("FCC"), to operate two types of technically identical Ku-band transmit/receive earth stations aboard aircraft ("ESAAs"), Call Sign E120106. Gogo seeks additional authorization for these aeronautical Ku-band earth stations to also utilize E117WA at 116.8° W.L. under the current ESAA rules including Section 25.227.

To the extent EAS has been informed by Gogo of the plans for ESAA to the present date, EAS certifies that the proposed use of the ESAA transmit/receive terminals at the power density levels provided by EAS is consistent with existing coordination agreements with all adjacent satellite operators within +/- 6 degrees of orbital separation from E117WA. EAS also acknowledges that the proposed operation of the Gogo ESAA terminal has the potential to create and receive harmful interference from adjacent satellite networks that may be unacceptable. If the FCC authorizes the operations proposed by Gogo, EAS will take into consideration the power density levels associated with the operation of Gogo in all future satellite network coordinations with other adjacent satellite operators, in accordance with the established international regulations.

The confirmation provided by this means shall be limited to the information provided by Gogo up to the present date. Should the information of Gogo be modified, the present letter shall not be valid until further analysis is completed and if required, EAS would provide the FCC with an updated letter reflecting any modification to the above.

Sincerely,

10-14-2015
Date

Hector Fortis
Eutelsat Americas
International and Regulatory Affairs

Eutelsat Americas |Av. Paseo de la Reforma No. 222 Pisos 20 y 21 | Col. Juárez CP 06600, Mexico, D.F. |

SKY Perfect JSAT Corporation

SKY Perfect JSAT Corporation
1-14-14, Akasaka, Minato-ku
Tokyo 107-0052, Japan
TEL +81-3-5571-7800

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

September 18, 2015

Re: Engineering Certification of JSAT Space Systems

To Whom It May Concern:

This letter confirms that JSAT is aware that Gogo LLC ("Gogo") is planning to seek a modification to its blanket authorization (the "Modification Application") from the Federal Communications Commission ("FCC") to operate two technically identical Ku band transmit/receive earth stations aboard aircraft ("ESAAs"), Call Sign E120106. Among other changes, the Modification Application will seek authority for Gogo's ESAA terminals to communicate with the JCSAT-2B sat" EL under the current ESAA rules including Section 25.227.

Based upon the representations made to JSAT by Gogo concerning the contents of its Modification Application:

- JSAT acknowledges that the proposed operation of the Gogo ESAA terminal has the potential to create harmful interference to satellite networks adjacent to JCSAT-2B that may be unacceptable.
- JSAT certifies that the proposed use of the ESAA transmit/receive terminals at the power density levels specified by Gogo are consistent with existing coordination agreements to which JSAT is a party with all adjacent satellite operators within +/- 6 degrees of orbital separation from JCSAT-2B.
- If the FCC authorizes the operations proposed by Gogo, JSAT will include the power density levels specified by Gogo in all future satellite network coordination with other operators of satellites adjacent to JCSAT-2B.

Sincerely,

M. Ishii

[Name] Mitsuru Ishii
[Title] General Manager, Mobile Business Division,
Space & Satellite Business Unit

SKY Perfect JSAT Corporation

SKY Perfect JSAT Corporation
1-14-14, Akasaka, Minato-ku
Tokyo 107-0052, Japan
TEL +81-3-5571-7800

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

September 18, 2015

Re: Engineering Certification of JSAT Space Systems

To Whom It May Concern:

This letter confirms that JSAT is aware that Gogo LLC ("Gogo") is planning to seek a modification to its blanket authorization (the "Modification Application") from the Federal Communications Commission ("FCC") to operate two technically identical Ku band transmit/receive earth stations aboard aircraft ("ESAAs"), Call Sign E120106. Among other changes, the Modification Application will seek authority for Gogo's ESAA terminals to communicate with the JCSAT-5A satellite at 132° EL under the current ESAA rules including Section 25.227.

Based upon the representations made to JSAT by Gogo concerning the contents of its Modification Application:

- JSAT acknowledges that the proposed operation of the Gogo ESAA terminal has the potential to create harmful interference to satellite networks adjacent to JCSAT-5A that may be unacceptable.
- JSAT certifies that the proposed use of the ESAA transmit/receive terminals at the power density levels specified by Gogo are consistent with existing coordination agreements to which JSAT is a party with all adjacent satellite operators within +/- 6 degrees of orbital separation from JCSAT-5A.
- If the FCC authorizes the operations proposed by Gogo, JSAT will include the power density levels specified by Gogo in all future satellite network coordination with other operators of satellites adjacent to JCSAT-5A.

Sincerely,

M. Ishii

[Name] Mitsuru Ishii
[Title] General Manager, Mobile Business Division,
Space & Satellite Business Unit

**ОТКРЫТОЕ
АКЦИОНЕРНОЕ ОБЩЕСТВО
«ГАЗПРОМ КОСМИЧЕСКИЕ СИСТЕМЫ»**

(ОАО «Газпром космические системы»)
а/я 1860, ОПС Щелково-12, Московская область, Российская Федерация, 141112
Тел.: (495) 5042906, (495) 5042907, факс: (495) 5042911
E-mail: info@gazprom-spacesystems.ru, www.gazprom-spacesystems.ru

**JOINT STOCK COMPANY
«GAZPROM SPACE SYSTEMS»**

(JSC Gazprom Space Systems)
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13.10.2015 №ИК-06/380/5067

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

September 15, 2015

Re: Engineering Certification of Gazprom Space Systems.

To Whom It May Concern:

This letter confirms that Gazprom Space Systems ("GSS") is aware that Gogo LLC ("Gogo") is planning to seek a modification to its blanket authorization (the "Modification Application") from the Federal Communications Commission ("FCC") to operate two types of technically identical Ku band transmit/receive earth stations aboard aircraft ("ESAAs"), Call Sign E120106. Among other changes, the Modification Application will seek authority for Gogo's ESAA terminals to communicate with the Yamal-300K satellite at 183°E under the current ESAA rules including Section 25.227.

Based upon the representations made to GSS by Gogo concerning the contents of its Modification Application:

- GSS acknowledges that the proposed operation of the Gogo ESAA terminal has the potential to create harmful interference to satellite networks adjacent to Yamal-300K that may be unacceptable. In order to ensure that such interference does not occur, Gogo and GSS have agreed to operational levels that are consistent with applicable coordination agreements.
- GSS certifies that the proposed use of the ESAA transmit/receive terminals at the power density levels specified by Gogo are consistent with existing coordination agreements to which GSS is a party with all adjacent satellite operators within +/- 6 degrees of orbital separation from Yamal-300K.

- If the FCC authorizes the operations proposed by Gogo, GSS will include the power density levels specified by Gogo in all future satellite network coordination's with other operators of satellites adjacent to Yamal-300K.

Best regards,

Igor Kot,
Deputy Director General

ОТКРЫТОЕ
АКЦИОНЕРНОЕ ОБЩЕСТВО
«ГАЗПРОМ КОСМИЧЕСКИЕ СИСТЕМЫ»

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JOINT STOCK COMPANY
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13.10.2015 № 11K-06/380/5069

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

September 15, 2015

Re: Engineering Certification of Gazprom Space Systems.

To Whom It May Concern:

This letter confirms that Gazprom Space Systems ("GSS") is aware that Gogo LLC ("Gogo") is planning to seek a modification to its blanket authorization (the "Modification Application") from the Federal Communications Commission ("FCC") to operate two types of technically identical Ku band transmit/receive earth stations aboard aircraft ("ESAAs"), Call Sign E120106. Among other changes, the Modification Application will seek authority for Gogo's ESAA terminals to communicate with the Yamal-401 satellite at 90°E under the current ESAA rules including Section 25.227.

Based upon the representations made to GSS by Gogo concerning the contents of its Modification Application:

- GSS acknowledges that the proposed operation of the Gogo ESAA terminal has the potential to create harmful interference to satellite networks adjacent to Yamal-401 that may be unacceptable. In order to ensure that such interference does not occur, Gogo and GSS have agreed to operational levels that are consistent with applicable coordination agreements.

- GSS certifies that the proposed use of the ESAA transmit/receive terminals at the power density levels specified by Gogo are consistent with existing coordination agreements to which GSS is a party with all adjacent satellite operators within +/- 6 degrees of orbital separation from Yamal-401.

- If the FCC authorizes the operations proposed by Gogo, GSS will include the power density levels specified by Gogo in all future satellite network coordination's with other operators of satellites adjacent to Yamal-401.

Best regards,

Igor Kot,
Deputy Director General

ASIASAT
Reaching Further, Bringing You Closer

Ref: TM21 /151015/0107

Federal Communications Commission
International Bureau
445 12th Street, S.W.
Washington, D.C. 20554

October 15, 2015

Re: Engineering Certification of Asiasat-7 Space Systems

To Whom It May Concern:

This letter confirms that Asiasat is aware that Gogo LLC ("Gogo") is planning to seek a modification to its blanket authorization (the "Modification Application") from the Federal Communications Commission ("FCC") to operate two technically identical Ku band transmit/receive earth stations aboard aircraft ("ESAAs"), Call Sign E120106. Among other changes, the Modification Application will seek authority for Gogo's ESAA terminals to communicate with the Asiasat -7 satellite at 105° EL. under the current ESAA rules including Section 25.227.

Based upon the representations made to Asiasat by Gogo concerning the contents of its Modification Application:

- Asiasat acknowledges that the proposed operation of the Gogo ESAA terminal has the potential to create harmful interference to satellite networks adjacent to Asiasat -7 that may be unacceptable.

- Asiasat certifies that the proposed use of the ESAA transmit/receive terminals at the power density levels specified by Gogo are consistent with existing coordination agreements to which ASIASAT is a party with all adjacent satellite operators within +/- 6 degrees of orbital separation from Asiasat -7.

- If the FCC authorizes the operations proposed by Gogo, Asiasat will include the power density levels jointly specified by Gogo and Asiasat in affected future satellite network coordination with other operators of satellites adjacent to Asiasat -7.

Sincerely,

NG Wai Fai
Manager, Communications Engineering

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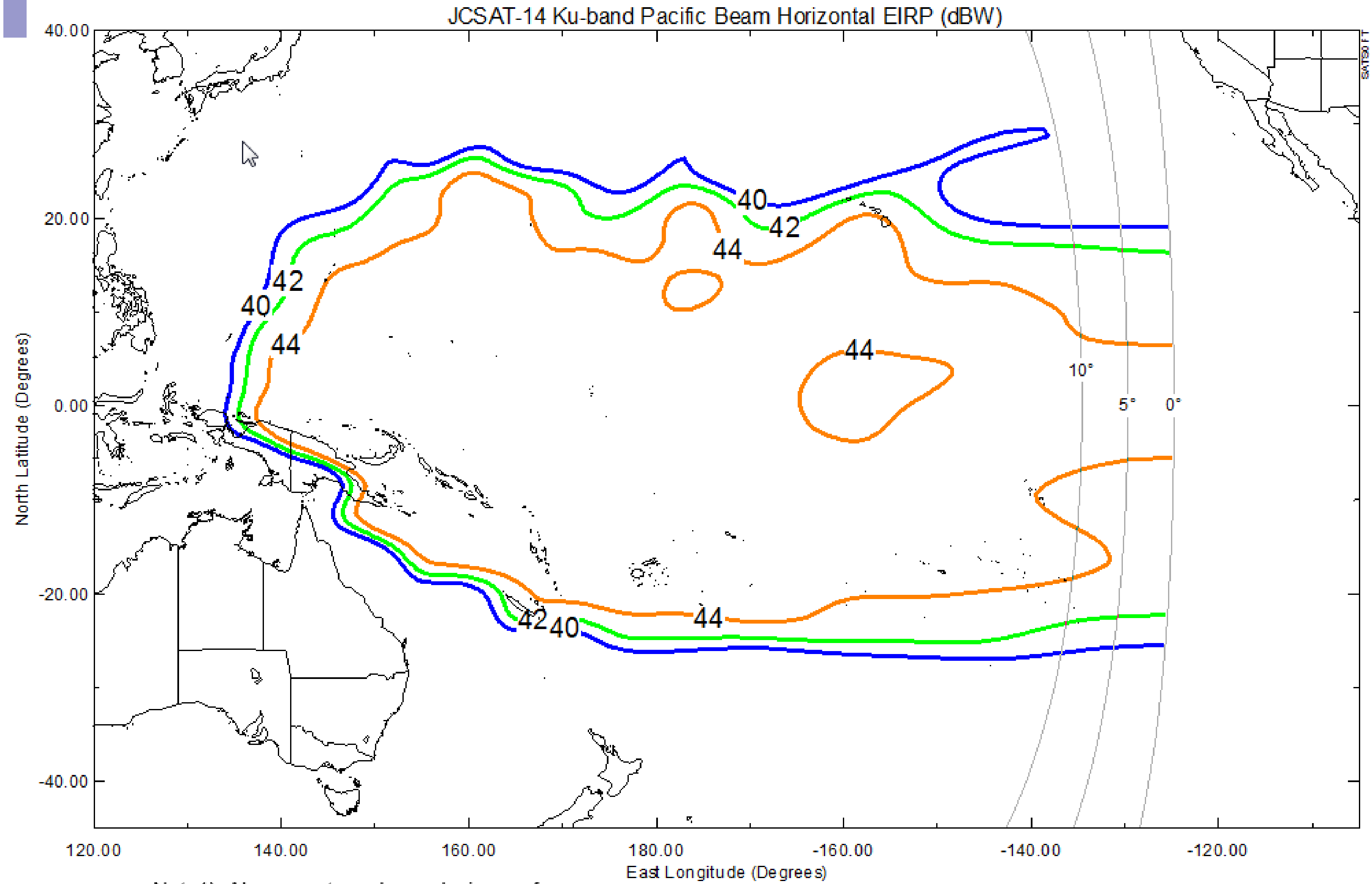
ANNEX 5: Coverage Maps, Link Budgets, and Orbital Debris Mitigation Statements

ANNEX 5.1.A: JCSAT-2B Coverage Map

JCSAT-2B (Pacific Beam) EIRP



Note1) Above contour shows design performance.

Note2) The performance may be changed at the planning phase.

SKY Perfect JSAT Corporation

6

AeroSat Antenna

Forward Link Budget

Hub	HPT - Hawaii	
Required Eb/No	3	dB
Modulation	QPSK	
Info Rate	4	Mbps
FEC Rate	0.693	
Carrier Rolloff	1.3	
Satellite SFD @ 0 dB/K	-90	dBW/m2
Transponder Atten	6	dB
Transponder ID	JCSAT-14 POR beam	

Hub Transmit

Frequency	14.2	GHz
Satellite G/T	-2	dB/oK
Antenna Diameter	8.1	m
Carrier EIRP	62.19	dBW
Ant. Input PFD	-26.11	dBW/4kHz
Path Loss	206.69	dB
Atm/Point/Pol Loss	0.14	dB

Aircraft Receive Terminal

Frequency	12.185	GHz
Satellite EIRP	44	dBW
Downlink PFD@ Beam Center(@42)	6.15	dBW/4kHz
Receive Gain	34.3	dB
Terminal G/T	11.66	dB/oK
Path Loss	205.3	dB
Other Losses	0.1	dB

Transponder

Total OPBO	3	dB
Carrier OPBO	9.24	dB
C/No Thermal Up	81.25	dB-Hz
C/No Thermal Dn	69.61	dB-Hz
C/Io Total	80.71	dB-Hz
C/No+Io	69.02	dB-Hz
Add'l Link Margin	0	dB
% BW per cxr	10.44	%
% Power per cxr	23.75	%
Xpdr BW Alloc	3.76	MHz

Return Link Budget

Terminal	Gogo AES-1	
Required Eb/No	3.7	dB
Modulation	BPSK	
Info Rate	1	Mbps
FEC Rate	0.5	
Carrier Spacing	1.2	
Carrier Spreading	2	
Satellite SFD @ 0 dB/K	-92	dBW/m2
Transponder Atten	4	dB
Transponder ID	JCSAT-14 POR beam	

Aircraft Transmit Terminal

Frequency	14.2	GHz
Satellite G/T	-2	dB/oK
Antenna Diameter	0.24	m
Carrier EIRP	44.52	dBW
Ant Input PFD	-14.49	dBW/4kHz
Path Loss	206.63	dB
Atm/Point/Pol Loss	0.06	dB

Hub Receive

Frequency	12.185	GHz
Satellite EIRP	44	dBW
Downlink PFD@ Beam Center(@44)	-10.14	dBW/4kHz
Hub G/T	37.22	dB/oK
Path Loss	205.36	dB
Other Losses	0.1	dB

Transponder

Total OPBO	3.06	dB
Carrier OPBO	24.130	dB
C/No Thermal Up	64.430	dB-Hz
C/No Thermal Dn	79.730	dB-Hz
C/Io Total	76.079	dB-Hz
C/No+Io	64.030	dB-Hz
Add'l Link Margin	0.33	dB
% BW per cxr	13.31	%
% Power per cxr	0.78	%
Xpdr BW Alloc	4.79	MHz

ANNEX 5.1.B: JCSAT-2B Link Budgets

ThinKom Antenna

Forward Link Budget

Hub	Hawaii	
Required Eb/No	3	dB
Modulation	QPSK	
Info Rate	4	Mbps
FEC Rate	0.693	
Carrier Rolloff	1.2	
Satellite SFD @ 0 dB/K	-91	dBW/m2
Transponder Atten	4	dB
Transponder ID	POR Beam	

Hub Transmit

Frequency	14.25	GHz
Satellite G/T	-3	dB/oK
Antenna Diameter	8.1	m
Carrier EIRP	61.09	dBW
Ant. Input PFD	-27.21	dBW/4kHz
Path Loss	207.24	dB
Atm/Point/Pol Loss	0.23	dB

Aircraft Receive Terminal

Frequency	12.185	GHz
Satellite EIRP	43	dBW
Downlink PFD@ Beam Center(@44)	4.4	dBW/4kHz
Receive Gain	30.57	dB
Terminal G/T	13.88	dB/oK
Path Loss	205.3	dB
Other Losses	0.05	dB

Transponder

Total OPBO	3.06	dB
Carrier OPBO	10	dB
C/No Thermal Up	78.53	dB-Hz
C/No Thermal Dn	70.13	dB-Hz
C/Io Total	81.71	dB-Hz
C/No+Io	69.28	dB-Hz
Add'l Link Margin	0.26	dB
% BW per cxr	9.62	%
% Power per cxr	20.22	%
Xpdr BW Alloc	3.464	MHz

Return Link Budget

Terminal	Gogo AES-2	
Required Eb/No	3.4	dB
Modulation	BPSK	
Info Rate	1	Mbps
FEC Rate	0.5	
Carrier Spacing	1.2	
Carrier Spreading	NA	
Satellite SFD @ 0 dB/K	-91	dBW/m2
Transponder Atten	4	dB
Transponder ID	POR Beam	

Aircraft Transmit Terminal

Frequency	14.25	GHz
Satellite G/T	-3	dB/oK
Antenna Diameter	0.74	m
Carrier EIRP	46.98	dBW
Ant Input PFD	-15.08	dBW/4kHz
Path Loss	206.66	dB
Atm/Point/Pol Loss	0.14	dB

Hub Receive

Frequency	12.185	GHz
Satellite EIRP	44	dBW
Downlink PFD@ Beam Center(@44)	-6.35	dBW/4kHz
Hub G/T	29.58	dB/oK
Path Loss	205.88	dB
Other Losses	0.17	dB

Transponder

Total OPBO	3.06	dB
Carrier OPBO	23.340	dB
C/No Thermal Up	65.180	dB-Hz
C/No Thermal Dn	71.300	dB-Hz
C/Io Total	75.690	dB-Hz
C/No+Io	63.930	dB-Hz
Add'l Link Margin	0.53	dB
% BW per cxr	6.67	%
% Power per cxr	0.94	%
Xpdr BW Alloc	2.4	MHz

ANNEX 5.1.C: JCSAT-2B Orbital Debris Mitigation Statement

SKY Perfect JSAT Corporation

MD-A-15-025

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JCSAT-2B Orbital Debris Mitigation Plan

This section addresses requirements contained in Section 25.114(d)(14)(i)-(iv) of the Commission's rules.

a. Debris Release Assessment-25.114(d)(14)(i). JSAT has assessed and limited the amount of debris released in a planned manner during normal operations and has assessed and limited the probability of the spacecraft becoming a source of debris by collisions with small debris or meteoroids.

The only phase of the mission in which portions of the spacecraft are separated from the main spacecraft body will be during deployment. During deployment, however, all separation and deployment mechanisms are designed to contain all debris generated when activated so as to ensure that no debris leaves the spacecraft. The assessment found no other sources for debris throughout the mission.

In the event of collisions with small debris or meteoroids, the spacecraft hardware has been designed with redundant units such that individual faults will not cause the loss of the entire spacecraft. All critical components (e.g., computers and control devices) are built within the structure and shielded from external influences. Items that could not be built within the spacecraft nor shielded (e.g., antennas) are able to withstand impact.

The spacecraft can be controlled through both the normal payload antenna and wide angle antennas. The likelihood of both being damaged during a small body collision is minimal.

b. Accidental Explosion Assessment-25.144(d)(14)(ii). JSAT has assessed and limited the probability of accidental explosions during and after completion of mission operations. The spacecraft employs the SSL 1300 satellite bus. This type of spacecraft has a history of successful on-orbit operations without fragmentation of the satellite into pieces of debris. All batteries and propellant tanks will be monitored for pressure or temperature variations. Alarms in the Satellite Control Center inform controllers of any variations. Additionally, long-term trending analysis will be performed to monitor for any unexpected

ANNEX 5.1.C: JCSAT-2B Orbital Debris Mitigation Statement

trends.

The batteries will be operated utilizing the manufacturer's automatic recharging scheme. Doing so ensures that charging terminates normally without building up additional heat and pressure. As this process occurs wholly within the spacecraft, it also affords protection from command link failures (on the ground).

In order to ensure that the spacecraft has no explosive risk after it has been successfully de-orbited, all stored energy sources onboard the spacecraft will be removed by venting excess propellant (Hydrazine, Oxidizer, and Xenon), and all propulsion lines and latch valves will be vented and left open. All battery chargers will be turned off and batteries will be left in a permanent discharge state. These steps will ensure that no buildup of energy can occur resulting in an explosion in the years after the spacecraft is de-orbited.

c. Assessment Regarding Collision with Large Debris and Other Space Stations-25.144(d)(14)(iii). JSAT has also assessed and limited the probability of the spacecraft becoming the source of debris by collisions with large debris or other operational space stations. The closest known spacecraft in the vicinity of JCSAT-2B are located at 152° E.L. and 156° E.L. Because JSAT will maintain JCSAT-2B within +/- 0.1 degrees of the assigned orbital position in both the longitude and latitude planes, risk of collision is negligible. In order to monitor nearby objects JSAT receives CDM (Conjunction Data Message) from JSpOC in a timely manner. As a result of CDM evaluation, collision avoidance operation will be implemented if needed.

d. Post-Mission Disposal Plans-25.144(d)(149(IV). Post-mission disposal of the satellite from operational orbit will be accomplished by maneuvering it to a 300km higher orbit. Propellant budget for this operation is included in the satellite design, and all propellants will be vented when accomplished.

See Appendix-A for details.

ANNEX 5.1.C: JCSAT-2B Orbital Debris Mitigation Statement

MD-A-15-025

Appendix-A Analysis for Post-Mission Disposal Plan

1) Post-mission disposal altitude

The minimum post-mission disposal altitude above the geostationary-Earth orbit is calculated as follows (using the IADC formula):

$235\ km + (1000 \cdot CR \cdot A/m) = 274.2\ km$

CR =1.23	JCSAT-2B Solar radiation pressure coefficient
$A = 68m^2$	JCSAT-2B Area based on deployed on-station configuration
M= 2136 kg	JCSAT-2B dry mass

Planned post-mission disposal altitude: 300km

Margin to minimum altitude requirement: 25.8km

2) Propellant budget for post-mission disposal

The amount of propellant reserved for the post-mission orbital raising is shown in the table below.

Disposal altitude	GEO + 300Km
Required Delta V	10.9m/s
Effective Isp	281 sec
Spacecraft Mass after orbital raising	2622.2 kg
Required propellant (reserved)	9.7 kg

The propellant budget is based on -3 sigma worst case analysis incorporating on-orbit performance deviations for the propulsion and attitude control subsystem.

In order to ensure the reserved propellant at the time of disposal, three propellant gauging methods are employed during on-orbit operations: Book-keeping, Pressure-Volume-Temperature (PVT) and Propellant Tank Thermal Capacity Gauging. Typical uncertainties of three gauging methods are shown in the table below. All three methods can be used and compared to track the remaining propellant in conservative approach throughout the mission life.

ANNEX 5.1.C: JCSAT-2B Orbital Debris Mitigation Statement

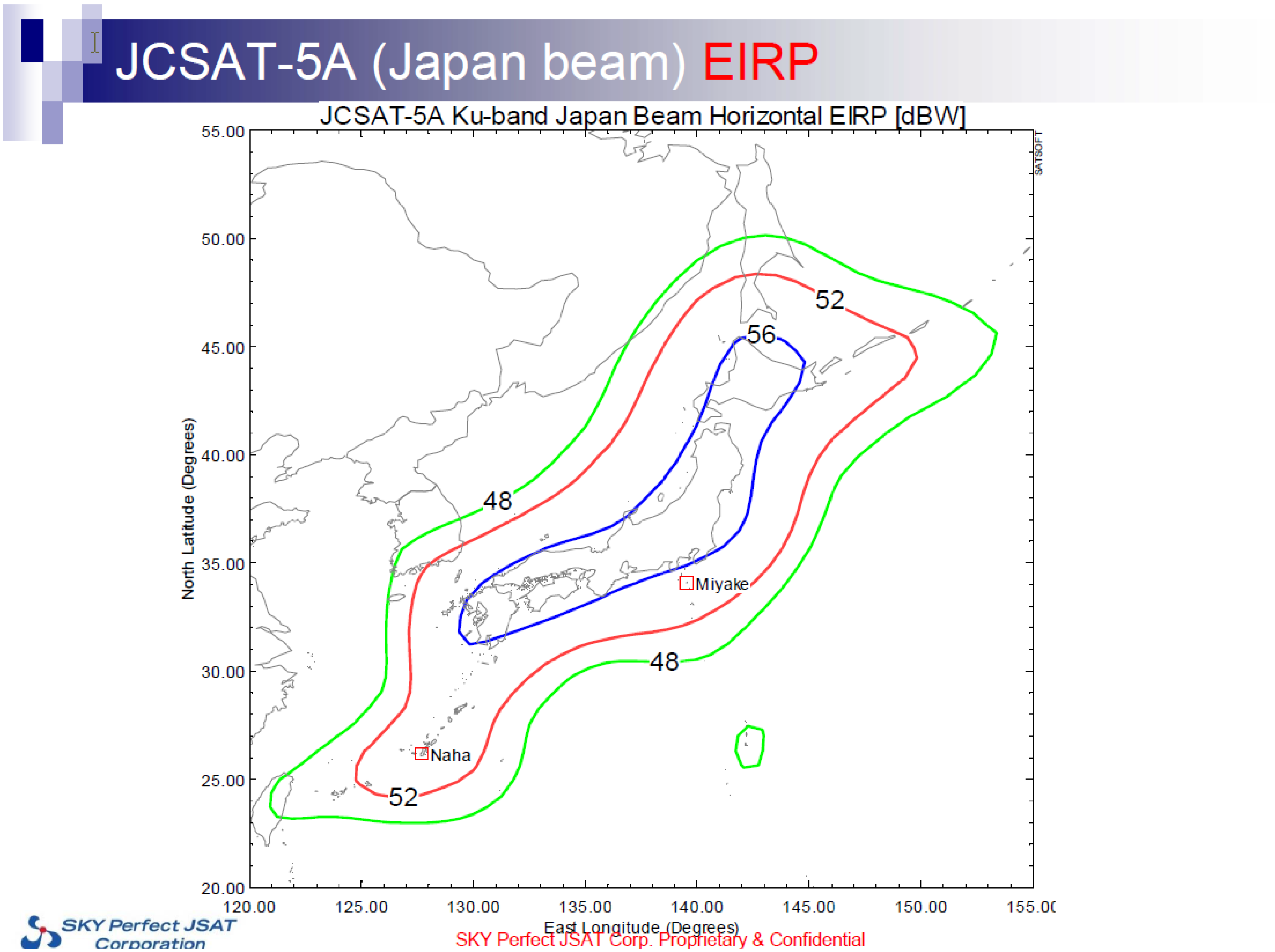
MD-A-15-025

Combination of Book-keeping and PVT method	+/- 10kg
Propellant Tank Thermal Capacity Gauging	+/- 2.5kg at ≤ 60 kg bipropellant remaining

SKY Perfect JSAT Corporation

Noriko Masuda
General Manager
Satellite Operation Division
9th October, 2015

ANNEX 5.2.A: JCSAT-5A Coverage Map



ANNEX 5.2.B: JCSAT-5A Link Budget

AeroSat Antenna

Forward Link Budget

Hub	Yokohama, Japan	
Required Eb/No	3.7	dB
Modulation	QPSK	
Info Rate	46.6	Mbps
FEC Rate	.76	
Carrier Rolloff	1.2	
Satellite SFD @ 0 dB/K	-109.1	dBW/m^2
Transponder Atten	26	dB
Transponder ID		
Hub Transmit		
Frequency	14.107	GHz
Satellite G/T	11.3	dB/°K
Antenna Diameter	7.6	m
Carrier EIRP	68.01	dBW
Ant. Input PFD	-29.65	dBW/4kHz
Path Loss	206.85	dB
Atm/Point/Pol Loss	.5	dB
Aircraft Receive Terminal		
Frequency	12.359	GHz
Satellite EIRP	54.2	dBW
Downlink PFD@ Beam Center	17.6	dBW/4kHz
Receive Gain	30.8	dB
Terminal G/T	11.7	dB/°K
Path Loss	205.7	dB
Other Losses	.6	dB
Transponder		
Total OPBO	0	dB
Carrier OPBO	.12	dB
C/No Thermal Up	100.94	dB-Hz
C/No Thermal Dn	88.37	dB-Hz
C/Io Total	83	dB-Hz
C/No+Io	81.5	dB-Hz
Add'l Link Margin	1.11	dB
% BW per cxr	100.00	%
% Power per cxr	100.00	%
Xpdr BW Alloc	36.00	MHz

Return Link Budget

Terminal	AES	
Required Eb/No	4.8	dB
Modulation	QPSK	
Info Rate	2500	Kbps
FEC Rate	.75	
Carrier Spacing	1.3	
Carrier Spreading	1.0	
Satellite SFD @ 0 dB/K	-109.1	dBW/m^2
Transponder Atten	17	dB
Transponder ID	LTWTA	
Aircraft Transmit		
Frequency	14.107	GHz
Satellite G/T	8.9	dB/°K
Antenna Diameter	0.24	m
Carrier EIRP	42.74	dBW
Ant Input PFD	-12.46	dBW/4kHz
Path Loss	206.72	dB
Atm/Point/Pol Loss	0.6	dB
Hub Receive		
Frequency	12.359	GHz
Satellite EIRP	56	dBW
Downlink PFD@ Beam Center	12.70	dBW/4kHz
Hub G/T	34.42	dB/°K
Path Loss	205.7	dB
Other Losses	.6	dB
Transponder		
Total OPBO	3.5	dB
Carrier OPBO	17.50	dB
C/No Thermal Up	72.82	dB-Hz
C/No Thermal Dn	95.24	dB-Hz
C/Io Total	73.48	dB-Hz
C/No+Io	70.11	dB-Hz
Add"l Link Margin	1.33	dB
% BW per cxr	6.0	%
% Power per cxr	3.98	%
Xpdr BW Alloc	2.17	MHz

ANNEX 5.2.C: JCSAT-5A Orbital Debris Mitigation Statement

SKY Perfect JSAT Corporation

MD-A-15-024

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TEL +81-3-5571-7800

JCSAT-5A Orbital Debris Mitigation Plan

This section addresses requirements contained in Section 25.114(d)(14)(i)-(iv) of the Commission's rules.

§25.114(d)(14)(i) – Spacecraft Hardware Design and Debris Release Assessment

JSAT has assessed and limited the amount of debris released in a planned manner during normal operations by the spacecraft. The only phase of the mission in which portions of the spacecraft are separated from the main spacecraft body was during deployment. During deployment, however, all separation and deployment mechanisms were designed to contain all debris generated when activated so as to ensure that no debris leaves the spacecraft. The assessment found no other sources for debris throughout the mission.

JSAT has also assessed and limited the probability of collisions with small debris or meteoroids. To protect from such small body collisions, the spacecraft hardware design of JCSAT-5A will allow for individual faults without losing the entire spacecraft.

All critical components (e.g., computers and control devices) are built within the structure and shielded from external influences. Items that could not be built within the spacecraft nor shielded (e.g., antennas) are able to withstand impact.

The spacecraft can be controlled through both the normal payload antenna and wide angle antennas. The likelihood of both being damaged during a small body collision is minimal. The wide angle antennas on this spacecraft are open waveguides that point towards the earth. There is one set on the Earth facing panel of the spacecraft and it could be used to successfully de-orbit the spacecraft.

§25.114(d)(14)(ii) - Accidental Explosion Assessment

JSAT has assessed and limited the probability of accidental explosions during and after completion of mission operations. JCSAT-5A is 3-axis stabilized and uses mono-propellant chemical propulsion for attitude and on-station control. JSAT has reviewed failure modes for all equipment to assess and limit the possibility of an accidental explosion onboard the spacecraft during and after completion of mission operations. To ensure that energy sources on board the spacecraft do not convert into energy that could fragment the spacecraft in orbit, JSAT is taking the following specific precautions.

All batteries and fuel tanks are monitored for pressure or temperature variations. Alarms on the JCSAT-5A satellite inform controllers of any variations. Batteries are operated utilizing the manufacturer's automatic recharging scheme to ensure that charging terminates normally without building up additional heat and pressure. As this process occurs wholly within the spacecraft, it also affords protection from command link failures (on the ground). Fuel tanks are operated in a blow down mode with one or two repressurizations during the mission.

On JCSAT-5A, the residual helium pressurant is stored in two identical pressure vessels, each with a volume of 4105(inch^3). The total end-of-life mass of helium is 6.12 kg, as calculated using tank temperatures and the common pressure for the system (tank and plumbing) received via telemetry data. (The range of temperature in kelvins used for the pressure calculation is from 263K to 323K.) The pressure of the helium tank is 720 – 790 psia based on telemetry data, and the vessels' maximum expected operating pressure is 4500 psia.

In order to ensure that the spacecraft has no explosive risk after it has been successfully de-orbited, all stored energy onboard the spacecraft will be removed, except for the quantity of inert helium pressurant noted above. All propulsion lines and latch valves will be vented and left open. All battery chargers will be turned off and batteries will be left in a permanent discharge state. These steps will ensure that no buildup of energy can occur resulting in an explosion in the years after the spacecraft is de-orbited.

§25.114(d)(14)(iii) – Safe Flight Profile and Assessment Regarding Collision with Larger Debris and Other Space Stations

JSAT has also assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. The satellite is located at orbital slot 132° E.L. The TT&C operation of JCSAT-5A satellite is performed by JSAT Satellite Control Center at all times through the ground station located in Yokohama, Japan. For station keeping, the satellite is maintained within a box of size of ±0.05 degree.

At this time there are no satellites located adjacent to JCSAT-5A such that station-keeping volumes might overlap. The closest satellites are, to the west, VINASAT-1 located at 131.9° E.L and VINASAT-2 located at 131.8° E.L. and, to the east, APSTAR-6 at 134° E.L.

§25.114(d)(14)(iv) – Post-Mission and End-of-Life Disposal Plans

ANNEX 5.2.C: JCSAT-5A Orbital Debris Mitigation Statement

MD-A-15-024

At the scheduled completion of its mission, JCSAT-5A will be removed from its geostationary orbit at 132° E.L. to the appropriate altitude above the standard geostationary orbit of 35,786 km. This altitude was determined by using the IADC formula of

Minimum Deorbit Altitude= 36,021 km + (1000•CR•A/m)
CR = solar pressure radiation coefficient of the spacecraft = 1.24
A/m = area to mass ratio, in square meters per kilogram, of the spacecraft = 0.0246
Result: (Eq.1) Minimum Deorbit Altitude = 36,021 km + (1000 * 1.24 * .0246) = 36,052 km which is
266 km above the geostationary orbit of 35,786 km.

This post-disposal perigee takes into account gravitational perturbations and solar radiation pressure that could alter the satellite orbit in the years after decommissioning.

JSAT will reserve sufficient propellant, inclusive of fuel gauging uncertainty, in order to conform to the IADC formula:

	Δa	Propellant needed
JCSAT-5A	266 km	12.9 kg

As the satellite is de-orbited, in accordance with to orbital raising operations, JSAT will configure the satellite with residual energy into a passive state. JSAT will implement procedures to eliminate on-board energy in whatever form of electrical, chemical, kinetic etc., which is considered as a potential source of generating harmful debris. These measures include shutting down the power generating subsystems and all power consumed components.

In addition, power to the reaction wheels will be disabled and they will eventually stop spinning, therefore retaining no kinetic energy. Pyrotechnic components would have been exhausted or completely disabled during operations in the initial stage of life. As such, we consider the risk of de-commissioning of the satellite will be kept minimal and conformed to the standard of the industry.

ANNEX 5.2.C: JCSAT-5A Orbital Debris Mitigation Statement

MD-A-15-024

Additional Information for JCSAT-5A

At the end of operational life, after the satellite has reached its final disposal orbit, onboard sources of energy will be depleted or secured, and the batteries will be discharged. However, at the end of its operational life, there will be oxidizer remaining in the tanks that cannot be vented. Following insertion of the spacecraft into orbit, the spacecraft manufacturer permanently sealed the oxidizer tanks by firing pyrotechnic valves. This is a design feature of the Lockheed A2100 series spacecraft that cannot now be changed or remedied. Information regarding the residual propellant in the tanks is as follows:

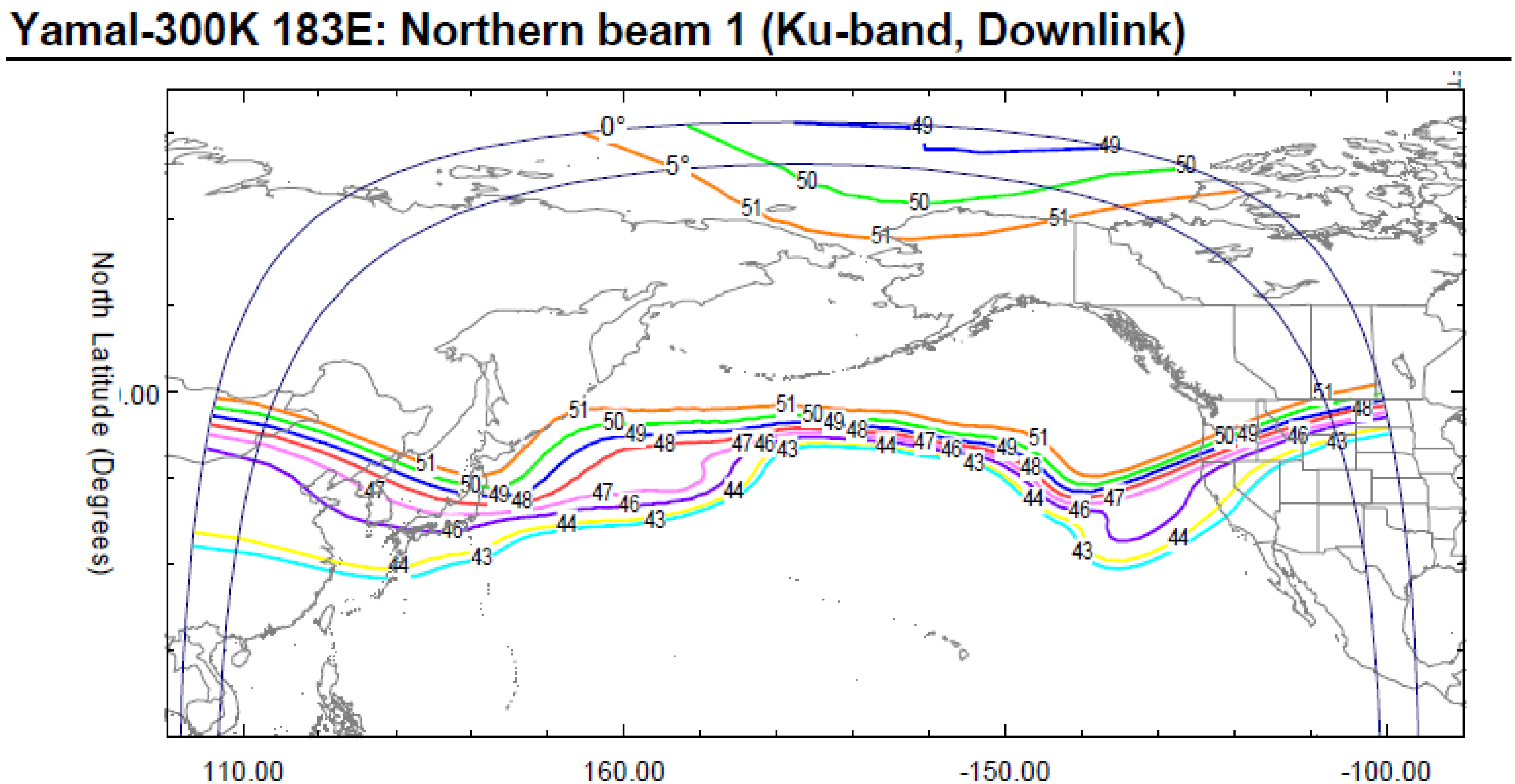
Item	Purpose	Tank Volume [inch^3]	Number of Tanks	Initial mass of item per tank [kg]	End of life mass [kg]	End of life pressure [psia]
Hydrazine	Orbit raising Orbit control Attitude control	92396	1	1450.0	38.15	NA(1)
Oxidizer	Orbit raising	20037	2 - Inter-connected	727.9	22.88	261 (18.0[bar])
Helium	Pressurant	4105	2 - Inter-connected	6.12	6.12	NA(1)

(1) – Not applicable, as after hydrazine depletion, hydrazine and helium pressures are not guaranteed, however, they will be as low as possible.

SKY Perfect JSAT Corporation

Noriko Masuda
General Manager
Satellite Operation Division
9th October, 2015

ANNEX 5.3.A: Yamal 300K Coverage Map



AeroSat Antenna

Forward Link Budget

Hub	Brewster, WA	
Required Eb/No	1.3	dB
Modulation	QPSK	
Info Rate	13.8	Mbps
FEC Rate	0.306	
Carrier Rolloff	1.2	
Satellite SFD @ 0 dB/K	-96.5	dBW/m²
Transponder Atten	8	dB
Transponder ID	LTWTA	

Hub Transmit

Frequency	14.0	GHz
Satellite G/T	0.5	dB/°K
Antenna Diameter	9.0	m
Carrier EIRP	66.9	dBW
Ant. Input PFD	-30.72	dBW/4kHz
Path Loss	207.6	dB
Atm/Point/Pol Loss	0.6	dB

Aircraft Receive Terminal

Frequency	11.0	GHz
Satellite EIRP	49.0	dBW
Downlink PFD@ Beam Center	7.26	dBW/4kHz
Receive Gain	31.9	dB
Terminal G/T	12.02	dB/°K
Path Loss	205.48	dB
Other Losses	.6	dB

Transponder

Total OPBO	3	dB
Carrier OPBO	6.74	dB
C/No Thermal Up	87.65	dB-Hz
C/No Thermal Dn	76.7	dB-Hz
C/Io Total	78.3	dB-Hz
C/No+Io	74.22	dB-Hz
Add'l Link Margin	1.53	dB
% BW per cxr	37.5	%
% Power per cxr	42.24	%
Xpdr BW Alloc	27.0	MHz

Return Link Budget

Terminal	AES 1	
Required Eb/No	3.5	dB
Modulation	BPSK	
Info Rate	1000	Kbps
FEC Rate	0.5	
Carrier Spacing	1.2	
Carrier Spreading	1.0	
Satellite SFD @ 0 dB/K	-96.5	dBW/m²
Transponder Atten	8	dB
Transponder ID	LTWTA	

Aircraft Transmit

Frequency	14.0	GHz
Satellite G/T	0.5	dB/°K
Antenna Diameter	0.24	m
Carrier EIRP	44.65	dBW
Ant Input PFD	-11.34	dBW/4kHz
Path Loss	207.2	dB
Atm/Point/Pol Loss	0.6	dB

Hub Receive

Frequency	11.0	GHz
Satellite EIRP	48.0	dBW
Downlink PFD@ Beam Center	-0.07	dBW/4kHz
Hub G/T	35.82	dB/°K
Path Loss	205.4	dB
Other Losses	.6	dB

Transponder

Total OPBO	3.0	dB
Carrier OPBO	28.50	dB
C/No Thermal Up	65.89	dB-Hz
C/No Thermal Dn	77.64	dB-Hz
C/Io Total	68.06	dB-Hz
C/No+Io	63.65	dB-Hz
Add'l Link Margin	0.15	dB
% BW per cxr	3.33	%
% Power per cxr	0.280	%
Xpdr BW Alloc	2.4	MHz

ANNEX 5.3.B: Yamal 300K Link Budgets

ThinKom Antenna

Forward Link Budget

Hub	Brewster, WA	
Required Eb/No	3.0	dB
Modulation	QPSK	
Info Rate	31.185	Mbps
FEC Rate	0.693	
Carrier Rolloff	1.2	
Satellite SFD @ 0 dB/K	-96.5	dBW/m^2
Transponder Atten	8	dB
Transponder ID	LTWTA	
Hub Transmit		
Frequency	14.0	GHz
Satellite G/T	0.5	dB/°K
Antenna Diameter	9.0	m
Carrier EIRP	65.74	dBW
Ant. Input PFD	-31.86	dBW/4kHz
Path Loss	207.5	dB
Atm/Point/Pol Loss	0.84	dB
Aircraft Receive Terminal		
Frequency	11.0	GHz
Satellite EIRP	49.0	dBW
Downlink PFD@ Beam Center	7.79	dBW/4kHz
Receive Gain	32.0	dB
Terminal G/T	13.03	dB/°K
Path Loss	204.9	dB
Other Losses	.6	dB
Transponder		
Total OPBO	3	dB
Carrier OPBO	6.21	dB
C/No Thermal Up	86.51	dB-Hz
C/No Thermal Dn	78.90	dB-Hz
C/Io Total	90.34	dB-Hz
C/No+Io	78.20	dB-Hz
Add'l Link Margin	0.01	dB
% BW per cxr	37.5	%
% Power per cxr	47.79	%
Xpdr BW Alloc	27.0	MHz

Return Link Budget

Terminal	AES-2	
Required Eb/No	3.5	dB
Modulation	BPSK	
Info Rate	1000	Kbps
FEC Rate	0.5	
Carrier Spacing	1.2	
Carrier Spreading	1.0	
Satellite SFD @ 0 dB/K	-96.5	dBW/m^2
Transponder Atten	8	dB
Transponder ID	LTWTA	
Aircraft Transmit		
Frequency	14.0	GHz
Satellite G/T	0.5	dB/°K
Antenna Diameter	0.74	m
Carrier EIRP	46.26	dBW
Ant Input PFD	-11.09	dBW/4kHz
Path Loss	207.0	dB
Atm/Point/Pol Loss	0.63	dB
Hub Receive		
Frequency	11.0	GHz
Satellite EIRP	48.0	dBW
Downlink PFD@ Beam Center(51.5)	-0.5	dBW/4kHz
Hub G/T	35.84	dB/°K
Path Loss	205.4	dB
Other Losses	.6	dB
Transponder		
Total OPBO	3.0	dB
Carrier OPBO	25.01	dB
C/No Thermal Up	67.71	dB-Hz
C/No Thermal Dn	81.07	dB-Hz
C/Io Total	69.76	dB-Hz
C/No+Io	65.48	dB-Hz
Add'l Link Margin	1.98	dB
% BW per cxr	3.33	%
% Power per cxr	0.63	%
Xpdr BW Alloc	2.4	MHz

ANNEX 5.3.C: Yamal 300K Orbital Debris Mitigation Statement

JSC Gazprom Space Systems ("GSS")
Yamal-300K Spacecraft

Technical Reference and
Orbital Debris Mitigation/End-of-Life Disposal Plan

1. Introduction

This Technical Reference and Orbital Debris Mitigation/End-of-Life Disposal Plan identifies the basic principles and operation of spacecraft Yamal-300K ("Yamal-300K") manufactured by JSC ISS by GSS supervision and contains information to ensure compliance with Russian State Standard GOST R 52925-2008 "Space Technologies, General Requirements to Space Systems to Limit Technogenic Pollution of Near-Earth Space" in the operation of spacecraft Yamal-300K to reduce GSO pollution.

In addition, this document has been prepared for the purpose of demonstrating the end of life disposal and debris mitigation policies associated with the spacecraft Yamal-300K in satisfaction of the Federal Communications Commission rules 47 C.F.R 25.114(d)(14) and 25.283(c).

2. General Information on Yamal-300K Spacecraft

Yamal-300K has been manufactured in compliance with applicable Russian standards and specifications and has a telecommunications payload manufactured by GSS. The spacecraft has an attitude and orbit control system based on thermocatalytic engines for spacecraft orientation (hydrazine propellant) and plasma thrusters for correction of the spacecraft orbit (xenon propellant). Yamal-300K was launched in November 2012; the estimated active lifetime is 15 years.

3. Operation of Yamal-300K

All materials used on spacecraft Yamal-300K are selected in compliance with GOST R 50109-92 and have minimum weight loss factors.

Operation of Yamal-300K in GSO, relocation to a new operating slot in GSO (if necessary), and de-orbit from GSO after completion of normal operation is carried out under constant supervision and control of the ballistic group of Yamal-300K Operations Control Center ("OCC"), which ensures security of the flight and prevents collisions with other spacecraft in orbit.

Yamal-300K is controlled continuously. Orbit correction is carried out in a standard way, in accordance with the orbit correction plan.

4. Orbital Debris Mitigation/End-of-Life Disposal Plan

a. §25.114(d)(14)(i) – Spacecraft Hardware Design and Debris Release Assessment

GSS has assessed the amount of debris released during normal operations by the spacecraft and determined that during operation in GSO and in the process of its deorbiting, any separations of structural or engine elements from Yamal-300K is impossible.

GSS has also assessed and limited the probability of collisions with debris or meteoroids. Flux density, sizes and other parameters of particles for GSO are specified by Russian documents defining spatiotemporal distribution of particles for MM (meteoric material) and TM (technogenic material) (GOST 25645.128 and OST 134-1022 accordingly). To protect from collisions with such small bodies, the spacecraft hardware design will allow for individual faults without losing the entire spacecraft. All critical components (*e.g.*, computers and control devices) are built within the structure and shielded from external influences. Items that could not be built within the spacecraft or shielded (e.g., antennas) are able to withstand the impact.

The spacecraft can be controlled through wide angle antennas. Antennas are made as open-ended waveguides and located by pairs at front and rear side panels of the spacecraft. Probability of both antenna pairs destruction by a single impact of a small body is negligible.

b. §25.114(d)(14)(ii) - Accidental Explosion Assessment

GSS has reviewed failure modes for all equipment onboard Yamal 300K to assess and limit the possibility of an accidental explosion onboard the spacecraft during and after completion of mission operations. To ensure that energy sources on board the spacecraft do not convert into energy that could fragment the spacecraft in orbit, GSS is taking the following measures.

All batteries are monitored for pressure or temperature variations, and the batteries are operated utilizing automatic recharging scheme to ensure that charging terminates normally without building up additional heat and pressure. As this process occurs wholly within the spacecraft, it also provides protection from command link failures (on the ground).

In order to protect the propulsion system, fuel tanks will be monitored in a blow down mode. This will cause the pressure in the tanks to decrease over the life of the spacecraft.

The onboard equipment includes tanks under pressure – xenon storage and hydrazine storage and supply tank. The possibility of such equipment destruction is virtually non-existent. This is ensured with significant safety margin between the fill pressure of the tank and the pressure rating for the tank, and has been proven with ground tests.

In order to ensure that the spacecraft has no explosive risk after it has been successfully de-orbited, all stored energy onboard the spacecraft will be removed. All battery chargers will be turned off and batteries will be left in a permanent discharge state. These steps will ensure that no power generation can occur resulting in an explosion in the years after the spacecraft is de-orbited.

c. §25.114(d)(14)(iii) – Safe Flight Profile and Assessment Regarding Collision with Larger Debris and Other Space Stations

GSS has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Yamal-300K operates in a geostationary orbit at the orbital position 183° E in accordance with the filings to ITU and in accordance with all ITU legal standards. Yamal-300K onboard systems and operation principles are organized in a way so that no single failure or wrongly issued command can lead to unauthorized engine start. Thus, a possibility of collision with other spacecraft due to the fault of GSS is minimized.

GSS will monitor scheduled launches to determine whether other satellites will be located in close proximity to Yamal 300K. If a new satellite is close to Yamal 300K, GSS will coordinate station keeping activities with the satellite operator to avoid any risk of collision.

d. §25.114(d)(14)(iv) and §25.283 -- Post-Mission and End-of-Life Disposal Plans

At the scheduled completion of its mission, Yamal 300K will be removed from its geostationary orbit at 183° E to a perigee altitude no less than 300 km above the standard geostationary orbit of 35,786 km. This altitude exceeds that determined by using the IADC formula included in section 25.283(a) of the FCC rules regarding end-of-life satellite disposal, as described in the attached Appendix.

Sufficient propellant, inclusive of fuel gauging uncertainty, will be reserved to ensure minimum de-orbit altitude is obtained. Any remaining propellant will be consumed by further raising the orbit.

Propellant tracking is accomplished using a bookkeeping method in which the ground control station tracks the number of jet seconds utilized for station keeping, momentum control and other attitude control events. The amount of fuel used is determined from the number of jet seconds. This process has been calibrated using data collected from thruster tests conducted on the ground and has been found to be accurate to within a few months of life on the spacecraft. Additional estimation of residual propellant is accomplished by telemetry data.

4. Yamal-300K De-Orbiting

At the end of its mission, Yamal 300K's post-disposal perigee takes into account gravitational perturbations and solar radiation pressure that could alter the satellite orbit in the years after decommissioning. GSS has planned the tracking telemetry and control transmissions required for end-of-life repositioning so as to avoid electrical interference to other space stations, and coordinated with any potentially affected satellite networks.

Finally, as discussed in Section (b) above, and except as detailed in the attached Appendix, all stored energy sources on board the satellite will be discharged by discharging batteries, and other appropriate measures.[1]

GSS provides for the following spacecraft deorbiting operations after its operation completion:

1. The calculations stipulate the necessary reserve of propellant for deorbiting the spacecraft after its operation completion.
2. Telemetry control of propulsion system propellant reserve is performed during the entire period of operation.
3. In accordance with GOST R 52925-2008, orbital radius to which the spacecraft is deorbited must be greater than the GSO radius by at least 235 km plus an additional factor. In view of the Yamal-300K characteristics and allowing for additional margin, the radius of the disposal orbit is customary to be greater than the radius of the geostationary orbit by 300 km. See Appendix.

[1] §25.283(c)

ANNEX 5.3.C: Yamal 300K Orbital Debris Mitigation Statement

4. After Yamal 300K is deorbited to the disposal orbit, it will be subject to passivation, specifically:

   - transfer of correction and orientation engines to inoperable condition (switching off the power supply);
   - de-spin momentum wheels and allow them to stop spinning (i.e., have no remaining kinetic energy)
   - fire all unfired pyrotechnic devices
   - final discharge of batteries at after deorbiting the spacecraft from GSO;
   - switch off of onboard equipment.

5. During deorbiting from GSO, operation of radio transmission line will be planned based on excluding the possibility of interference in the frequencies of other spacecraft.

Igor Kot
Deputy Director General

APPENDIX

Yamal 300K will be removed from its geostationary orbit at 183E at a perigee altitude no less than 300 km above the standard geostationary orbit of 35786 km. This altitude exceeds that arrived at by using the equation in §25.283 of the FCC rules pertaining to end-of-life satellite disposal (minimum altitude= 235 km + (1000•CR•A/m)) above geostationary orbit).

Minimum Deorbit Altitude= 36,021 km + (1000•CR•A/m)
CR = solar pressure radiation coefficient of the spacecraft = 1.25
A/m = area to mass ratio, in square meters per kilogram, of the spacecraft = 0.028

Result:
Minimum Deorbit Altitude = 36,021 km + (1000•.1.25• 0.028) = 36, 056 km
or 270 km above the geostationary arc

De-orbiting the satellite at 300km or above provides additional margin to the minimum de-orbit altitude. The propellant needed to achieve the minimum deorbit altitude is based on the delta-V required and specified by the spacecraft manufacturer.

Based on IADC calculation, an estimated end-of-life mass of 1684.4 kg, and the delta-V required of approximately 11.1 m/s, 1.8 kg of propellant will be reserved to ensure minimum de-orbit altitude is obtained. It should be noted that Yamal 300K utilizes Xips thrusters (instead of normal bi-propellant). Xenon is the basic fuel type, which is much more efficient.

Any remaining propellant will be consumed by further raising the orbit until combustion is no longer possible.

By the moment of complete spacecraft deactivation residual propellant on the board shall be as follows:

Item	Purpose	Tank Volume	Number of Tanks / Interconnected	Initial mass of item per tank	End of life mass / volume	Tank pressure rating / units	End of life pressure
Hydrazine (liquid)	Attitude control	26 liters BOL 0.7 litre EOL	Located in common tank and separated by internal membrane.	25 kg	0.7 kg/ 0.7 l	9.0 atm	NA (1)
Nitrogen	Pressurant	14 liters BOL 40 liters EOL		0.25 kg	0.25 kg/ 39,3 l	9,0 atm	2.1 atm
Xenon	Orbit control	38 liters	2 / Yes	71 kg in each tank	1 kg in each tank	140 atm	2.6 atm

(1) – Not applicable, as after hydrazine depletion, membrane-separator of hydrazine and pressurant is completely folded and hydrazine pressure is not guaranteed (at the worst, it does not exceed Nitrogen pressure)

In the case of Xenon propellant, please note that the tanks are interconnected and the residual products are stated as the total dispersed between all tanks. The residual pressures above assume a temperature of 293 degrees K.

During manufacturing the tanks are tested by the pressure 1.5 times higher than fill pressure.

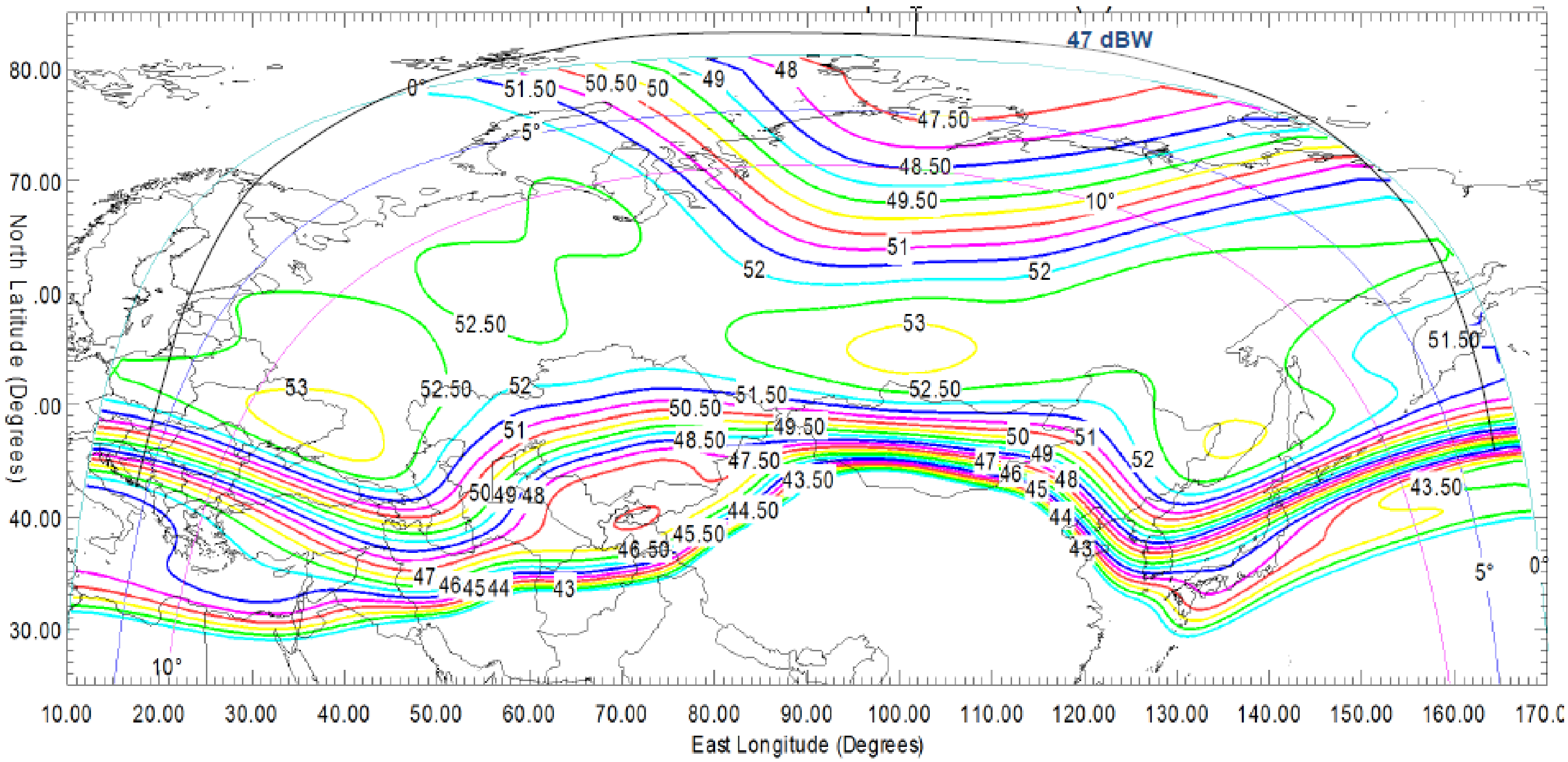
5

ANNEX 5.4.A: Yamal 401 Coverage Map

Yamal-401 Technical user guide

GAZPROM SPACE SYSTEMS

Yamal-401 90°E Downlink coverage- Northern beam (Ku-band)



Downlink band: 10.950 - 11.200 GHz
11.450 - 11.700 GHz
12.500 – 12.750 GHz

AeroSat Antenna

Forward Link Budget

Hub	Moscow, Russia	
Required Eb/No	1.3	dB
Modulation	QPSK	
Info Rate	4000	Kbps
FEC Rate	.31	
Carrier Rolloff	1.3	
Satellite SFD @ 0 dB/K	-95.52	dBW/m²
Transponder Atten	8	dB
Transponder ID	Northern Beam	
Hub Transmit		
Frequency	14.093	GHz
Satellite G/T	5	dB/°K
Antenna Diameter	9.3	m
Carrier EIRP	57.43	dBW
Ant. Input PFD	-35.10	dBW/4kHz
Path Loss	207.57	dB
Atm/Point/Pol Loss	.7	dB
Aircraft Receive Terminal		
Frequency	11.793	GHz
Satellite EIRP	49.5	dBW
Downlink PFD@ Beam Center	10.44	dBW/4kHz
Receive Gain	32	dB
Terminal G/T	10.75	dB/°K
Path Loss	206.13	dB
Other Losses	1.3	dB
Transponder		
Total OPBO	3.0	dB
Carrier OPBO	10.93	dB
C/No Thermal Up	82.67	dB-Hz
C/No Thermal Dn	70.32	dB-Hz
C/Io Total	72.63	dB-Hz
C/No+Io	68.16	dB-Hz
Add'l Link Margin	0.84	dB
% BW per cxr	11.8	%
% Power per cxr	16.11	%
Xpdr BW Alloc	8.5	MHz

Return Link Budget

Terminal	AES-1	
Required Eb/No	3.5	dB
Modulation	BPSK	
Info Rate	1000	Kbps
FEC Rate	1/2	
Carrier Spacing	1.3	
Carrier Spreading	1.0	
Satellite SFD @ 0 dB/K	-95.5	dBW/m²
Transponder Atten	8	dB
Transponder ID	Northern Beam	
Aircraft Transmit Terminal		
Frequency	14.093	GHz
Satellite G/T	3.50	dB/°K
Antenna Diameter	0.24	m
Carrier EIRP	44.5	dBW
Ant Input PFD	-11.49	dBW/4kHz
Path Loss	207.8	dB
Atm/Point/Pol Loss	0.7	dB
Hub Receive		
Frequency	11.793	GHz
Satellite EIRP	52.0	dBW
Downlink PFD@ Beam Center	-0.49	dBW/4kHz
Hub G/T	35.17	dB/°K
Path Loss	206.14	dB
Other Losses	0.6	dB
Transponder		
Total OPBO	3.0	dB
Carrier OPBO	25.5	dB
C/No Thermal Up	68.1	dB-Hz
C/No Thermal Dn	83.5	dB-Hz
C/Io Total	69.03	dB-Hz
C/No+Io	65.46	dB-Hz
Add'l Link Margin	1.96	dB
% BW per cxr	3.33	%
% Power per cxr	.56	%
Xpdr BW Alloc	2.4	MHz

ThinKom Antenna

Forward Link Budget

Hub	Moscow, Russia	
Required Eb/No	1.7	dB
Modulation	QPSK	
Info Rate	5.6	Mbps
FEC Rate	0.5	
Carrier Rolloff	1.2	
Satellite SFD @ 0 dB/K	-95.5	dBW/m²
Transponder Atten	8	dB
Transponder ID	No. Beam 1	

Hub Transmit

Frequency	14.0	GHz
Satellite G/T	5.0	dB/°K
Antenna Diameter	9.3	m
Carrier EIRP	60.85	dBW
Ant. Input PFD	-34.28	dBW/4kHz
Path Loss	207.5	dB
Atm/Point/Pol Loss	1.05	dB

Aircraft Receive Terminal

Frequency	11.7	GHz
Satellite EIRP	45.75	dBW
Downlink PFD@ Beam Center	9.41	dBW/4kHz
Receive Gain	32.93	dB
Terminal G/T	15.23	dB/°K
Path Loss	205.5	dB
Other Losses	.6	dB

Transponder

Total OPBO	3	dB
Carrier OPBO	10.63	dB
C/No Thermal Up	82.94	dB-Hz
C/No Thermal Dn	72.52	dB-Hz
C/Io Total	72.24	dB-Hz
C/No+Io	69.18	dB-Hz
Add'l Link Margin	0.0	dB
% BW per cxr	9.33	%
% Power per cxr	17.26	%
Xpdr BW Alloc	6.72	MHz

Return Link Budget

Terminal	AES (2Ku)	
Required Eb/No	3.5	dB
Modulation	BPSK	
Info Rate	1500	Kbps
FEC Rate	0.5	
Carrier Spacing	1.2	
Carrier Spreading	1.0	
Satellite SFD @ 0 dB/K	-95.5	dBW/m²
Transponder Atten	8	dB
Transponder ID	No Beam 1	

Aircraft Transmit

Frequency	14.0	GHz
Satellite G/T	- 0.5	dB/°K
Antenna Diameter	0.74	m
Carrier EIRP	46.1	dBW
Ant Input PFD	-14.74	dBW/4kHz
Path Loss	207.0	dB
Atm/Point/Pol Loss	0.6	dB

Hub Receive

Frequency	11.7	GHz
Satellite EIRP	51.5	dBW
Downlink PFD@ Beam Center	-4.59	dBW/4kHz
Hub G/T	35.82	dB/°K
Path Loss	205.9	dB
Other Losses	.6	dB

Transponder

Total OPBO	3.0	dB
Carrier OPBO	27.34	dB
C/No Thermal Up	66.23	dB-Hz
C/No Thermal Dn	81.47	dB-Hz
C/Io Total	73.45	dB-Hz
C/No+Io	65.37	dB-Hz
Add'l Link Margin	0.1	dB
% BW per cxr	5.0	%
% Power per cxr	0.37	%
Xpdr BW Alloc	3.6	MHz

ANNEX 5.4.C: Yamal 401 Orbital Debris Mitigation Statement

JSC Gazprom Space Systems
Yamal-401 Spacecraft

Technical Reference and
Orbital Debris Mitigation/End-of-Life Disposal Plan

1. Introduction

This Technical Reference and Orbital Debris Mitigation/End-of-Life Disposal Plan identifies the basic principles and operation of spacecraft Yamal-401 ("Yamal-401") manufactured by JSC Information Satellite Systems ("ISS") and contains information to ensure compliance with Russian State Standard GOST R 52925-2008 "Space Technologies, General Requirements to Space Systems to Limit Technogenic Pollution of Near-Earth Space" in the operation of spacecraft Yamal-401 to reduce GSO pollution.

In addition, this document has been prepared for the purpose of demonstrating the end of life disposal and debris mitigation policies associated with the spacecraft Yamal-401 in satisfaction of the Federal Communications Commission rules 47 C.F.R 25.114(d)(14) and 25.283(c).

2. General Information on Yamal-401 Spacecraft

Yamal-401 has been manufactured in compliance with applicable Russian standards and specifications and has a telecommunications payload manufactured by GSS. The spacecraft has an attitude and orbit control system based on thermocatalytic engines for spacecraft orientation (hydrazine propellant) and plasma thrusters for correction of the spacecraft orbit (xenon propellant). Yamal-401 was launched in December 2014; the estimated active lifetime is 15 years.

3. Operation of Yamal-401

All materials used on spacecraft Yamal-401 are selected in compliance with GOST R 50109-92 and have minimum weight loss factors.

Operation of Yamal-401 in GSO, relocation to a new operating slot in GSO (if necessary), and de-orbit from GSO after completion of normal operation is carried out under constant supervision and control of the ballistic group of Yamal-401 Operations Control Center ("OCC"), which ensures security of the flight and prevents collisions with other spacecraft in orbit.

Yamal-401 is controlled continuously. Orbit correction is carried out in a standard way, in accordance with the orbit correction plan.

4. Orbital Debris Mitigation/End-of-Life Disposal Plan

a. §25.114(d)(14)(i) – Spacecraft Hardware Design and Debris Release Assessment

GSS has assessed the amount of debris released during normal operations by the spacecraft and determined that during operation in GSO and in the process of its deorbiting, any separations of structural or engine elements from Yamal-401 is impossible.

GSS has also assessed and limited the probability of collisions with debris or meteoroids. Flux density, sizes and other parameters of particles for GSO are specified by Russian documents defining spatiotemporal distribution of particles for MM (meteoric material) and TM (technogenic material) (GOST 25645.128 and OST 134-1022 accordingly). To protect from collisions with such small bodies, the spacecraft hardware design will allow for individual faults without losing the entire spacecraft. All critical components (*e.g.*, computers and control devices) are built within the structure and shielded from external influences. Items that could not be built within the spacecraft or shielded (e.g., antennas) are able to withstand the impact.

The spacecraft can be controlled through wide angle antennas. Antennas are made as open-ended waveguides and located by pairs at front and rear side panels of the spacecraft. Probability of both antenna pairs destruction by a single impact of a small body is negligible.

b. §25.114(d)(14)(ii) - Accidental Explosion Assessment

GSS has reviewed failure modes for all equipment onboard Yamal-401 to assess and limit the possibility of an accidental explosion onboard the spacecraft during and after completion of mission operations. To ensure that energy sources on board the spacecraft do not convert into energy that could fragment the spacecraft in orbit, GSS is taking the following measures.

All batteries are monitored for pressure or temperature variations, and the batteries are operated utilizing automatic recharging scheme to ensure that charging terminates normally without building up additional heat and pressure. As this process occurs wholly within the spacecraft, it also provides protection from command link failures (on the ground).

In order to protect the propulsion system, fuel tanks will be monitored in a blow down mode. This will cause the pressure in the tanks to decrease over the life of the spacecraft.

The onboard equipment includes tanks under pressure – xenon storage and hydrazine storage and supply tank. The possibility of such equipment destruction is virtually non-existent. This is ensured with significant safety margin between the fill pressure of the tank and the pressure rating for the tank, and has been proven with ground tests.

In order to ensure that the spacecraft has no explosive risk after it has been successfully de-orbited, all stored energy onboard the spacecraft will be removed. All battery chargers will be turned off and batteries will be left in a permanent discharge state. These steps will ensure that no power generation can occur resulting in an explosion in the years after the spacecraft is de-orbited.

c. §25.114(d)(14)(iii) – Safe Flight Profile and Assessment Regarding Collision with Larger Debris and Other Space Stations

GSS has assessed and limited the probability of the spacecraft becoming a source of debris by collisions with large debris or other operational spacecrafts. Yamal-401 operates in a geostationary orbit at the orbital position 90° E in accordance with the filings to ITU and in accordance with all ITU legal standards. Yamal-401 onboard systems and operation principles are organized in a way so that no single failure or wrongly issued command can lead to unauthorized engine start. Thus, a possibility of collision with other spacecraft due to the fault of GSS is minimized.

GSS will monitor scheduled launches to determine whether other satellites will be located in close proximity to Yamal-401. If a new satellite is close to Yamal-401, GSS will coordinate station keeping activities with the satellite operator to avoid any risk of collision.

d. §25.114(d)(14)(iv) and §25.283 -- Post-Mission and End-of-Life Disposal Plans

At the scheduled completion of its mission, Yamal-401 will be removed from its geostationary orbit at 90° E to a perigee altitude no less than 300 km above the standard geostationary orbit of 35,786 km. This altitude exceeds that determined by using the IADC formula included in section 25.283(a) of the FCC rules regarding end-of-life satellite disposal, as described in the attached Appendix.

Sufficient propellant, inclusive of fuel gauging uncertainty, will be reserved to ensure minimum de-orbit altitude is obtained. Any remaining propellant will be consumed by further raising the orbit.

Propellant tracking is accomplished using a bookkeeping method in which the ground control station tracks the number of jet seconds utilized for station keeping, momentum control and other attitude control events. The amount of fuel used is determined from the number of jet seconds. This process has been calibrated using data collected from thruster tests conducted on the ground and has been found to be accurate to within a few months of life on the spacecraft. Additional estimation of residual propellant is accomplished by telemetry data.

4. Yamal-401 De-Orbiting

At the end of its mission, Yamal-401's post-disposal perigee takes into account gravitational perturbations and solar radiation pressure that could alter the satellite orbit in the years after decommissioning. GSS has planned the tracking telemetry and control transmissions required for end-of-life repositioning so as to avoid electrical interference to other spacecrafts, and coordinated with any potentially affected satellite networks.

Finally, as discussed in Section (b) above, and except as detailed in the attached Appendix, all stored energy sources on board the satellite will be discharged by discharging batteries, and other appropriate measures.[1]

GSS provides for the following spacecraft deorbiting operations after its operation completion:

1. The calculations stipulate the necessary reserve of propellant for deorbiting the spacecraft after its operation completion.

2. Telemetry control of propulsion system propellant reserve is performed during the entire period of operation.

3. In accordance with GOST R 52925-2008, orbital radius to which the spacecraft is deorbited must be greater than the GSO radius by at least 235 km plus an additional factor. In view of the Yamal-401 characteristics and allowing for additional margin, the radius of the disposal orbit is customary to be greater than the radius of the geostationary orbit by 300 km. See Appendix.

[1] §25.283(c)

4. After Yamal-401 is deorbited to the disposal orbit, it will be subject to passivation, specifically:

    - transfer of correction and orientation engines to inoperable condition (switching off the power supply);
    - de-spin momentum wheels and allow them to stop spinning (i.e., have no remaining kinetic energy)
    - fire all unfired pyrotechnic devices
    - final discharge of batteries at after deorbiting the spacecraft from GSO;
    - switch off of onboard equipment.

5. During deorbiting from GSO, operation of radio transmission line will be planned based on excluding the possibility of interference in the frequencies of other spacecraft.

Igor Kot
Deputy Director General

APPENDIX

Yamal-401 will be removed from its geostationary orbit at 90E at a perigee altitude no less than 300 km above the standard geostationary orbit of 35786 km. This altitude exceeds that arrived at by using the equation in §25.283 of the FCC rules pertaining to end-of-life satellite disposal (minimum altitude= 235 km + (1000•CR•A/m)) above geostationary orbit).

Minimum Deorbit Altitude= 36,021 km + (1000•CR•A/m)
CR = solar pressure radiation coefficient of the spacecraft = 1.25
A/m = area to mass ratio, in square meters per kilogram, of the spacecraft = 0.032

Result:
Minimum Deorbit Altitude = 36,021 km + (1000•.1.25• 0.032) = 36, 061 km
or 270 km above the geostationary arc

De-orbiting the satellite at 300 km or above provides additional margin to the minimum de-orbit altitude. The propellant needed to achieve the minimum deorbit altitude is based on the delta-V required and specified by the spacecraft manufacturer.

Based on IADC calculation, an estimated end-of-life mass of 2688 kg, and the delta-V required of approximately 11.1 m/s, 3.08 kg of propellant will be reserved to ensure minimum de-orbit altitude is obtained. It should be noted that Yamal-401 utilizes Xips thrusters (instead of normal bi-propellant). Xenon is the basic fuel type, which is much more efficient.

Any remaining propellant will be consumed by further raising the orbit until combustion is no longer possible.

By the moment of complete spacecraft deactivation residual propellant on the board shall be as follows:

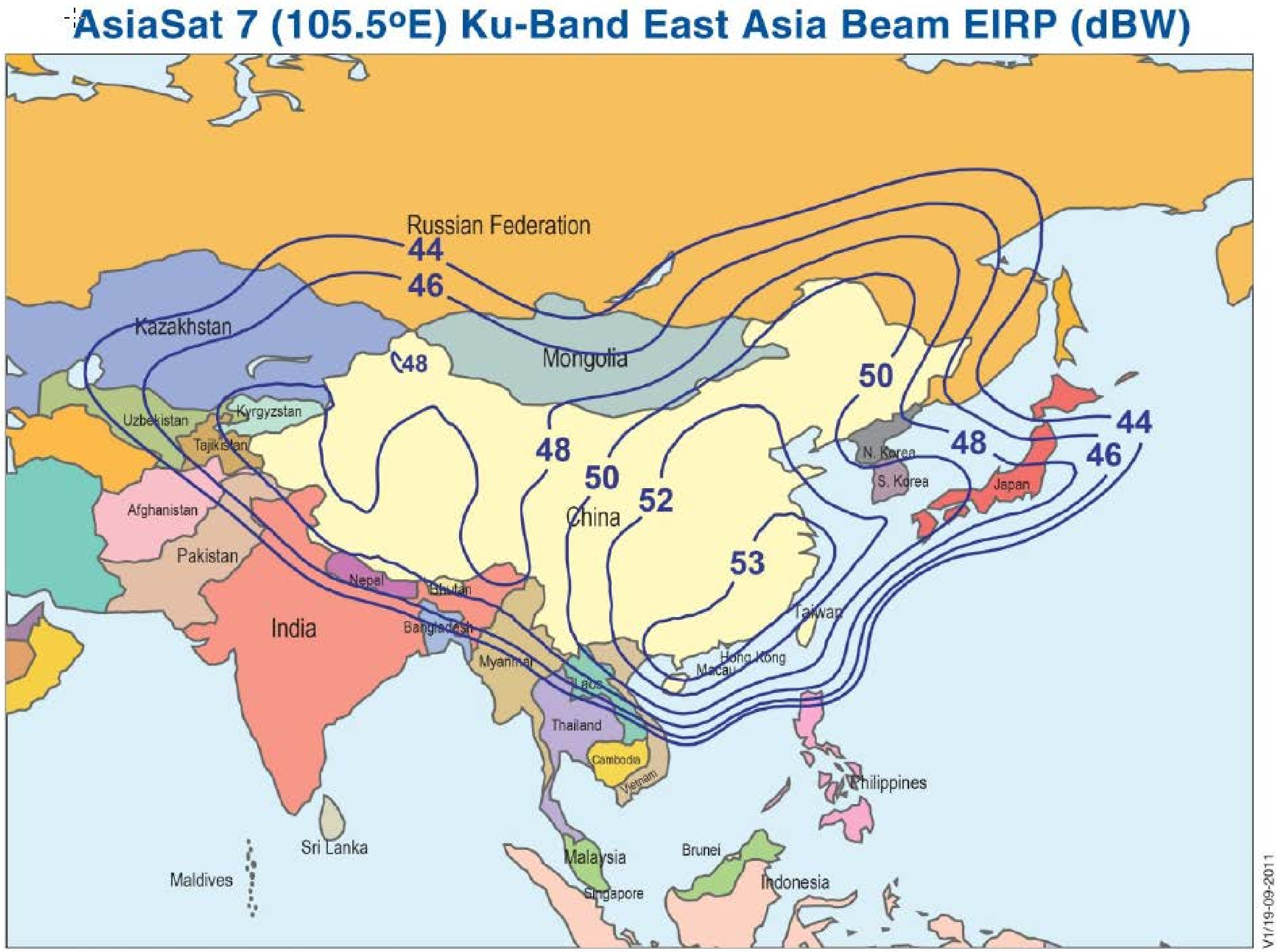
Item	Purpose	Tank Volume	Number of Tanks / Interconnected	Initial mass of item per tank	End of life mass / volume	Tank pressure rating / units	End of life pressure
Hydrazine (liquid)	Attitude control	26 liters BOL 0.7 litre EOL	3 Tanks / Interconnected Fuel and pressurant are located in common tank and separated by internal membrane.	25 kg	0.7 kg/ 0.7 l	9.0 atm	NA (1)
Nitrogen	Pressurant	14 liters BOL 40 liters EOL		0.25 kg	0.25 kg/ 39,3 l	9,0 atm	2.1 atm
Xenon	Orbit control	38 liters	4 / Yes	71 kg in each tank	1 kg in each tank	140 atm	2.6 atm

(1) – Not applicable, as after hydrazine depletion, membrane-separator of hydrazine and pressurant is completely folded and hydrazine pressure is not guaranteed (at the worst, it does not exceed Nitrogen pressure)

In the case of Xenon propellant, please note that the tanks are interconnected and the residual products are stated as the total dispersed between all tanks. The residual pressures above assume a temperature of 293 degrees K.

During manufacturing the tanks are tested by the pressure 1.5 times higher than fill pressure.

ANNEX 5.5.A: AsiaSat 7 Coverage Map



Note : Technical data is for reference only.
AsiaSat Proprietary

ANNEX 5.5.B: AsiaSat 7 Link Budgets

AeroSat Antenna

Forward Link Budget

Hub	Beijing HUB	
Required Eb/No	1.7	dB
Modulation	QPSK	
Info Rate	4	Mbps
FEC Rate	0.5	
Carrier Rolloff	1.2	
Satellite SFD @ 0 dB/K	-98.4	dBW/m2
Transponder Atten	8	dB
Transponder ID	East Asia Beam	

Hub Transmit

Frequency	14.145	GHz
Satellite G/T	5.4	dB/oK
Antenna Diameter	6.3	m
Carrier EIRP	51.21	dBW
Ant. Input PFD	-35.62	dBW/4kHz
Path Loss	206.96	dB
Atm/Point/Pol Loss	0.12	dB

Aircraft Receive Terminal

Frequency	11.8	GHz
Satellite EIRP	46	dBW
Downlink PFD@ Beam Center(@52.4)	5.29	dBW/4kHz
Receive Gain	31.84	dB
Terminal G/T	11.81	dB/oK
Path Loss	205.57	dB
Other Losses	0.11	dB

Transponder

Total OPBO	3	dB
Carrier OPBO	10.69	dB
C/No Thermal Up	77.44	dB-Hz
C/No Thermal Dn	69.44	dB-Hz
C/Io Total	74.31	dB-Hz
C/No+Io	67.72	dB-Hz
Add'l Link Margin	0	dB
% BW per cxr	8.89	%
% Power per cxr	17.01	%
Xpdr BW Alloc	54	MHz

Return Link Budget

Terminal	Gogo AES-1	
Required Eb/No	3.5	dB
Modulation	BPSK	
Info Rate	0.512	Mbps
FEC Rate	0.5	
Carrier Spacing	1.2	
Carrier Spreading	2	
Satellite SFD @ 0 dB/K	-94	dBW/m2
Transponder Atten	7	dB
Transponder ID	East Asia Beam	

Aircraft Transmit Terminal

Frequency	14.145	GHz
Satellite G/T	0	dB/oK
Antenna Diameter	0.24	m
Carrier EIRP	44.52	dBW
Ant Input PFD	-11.58	dBW/4kHz
Path Loss	207.14	dB
Atm/Point/Pol Loss	0.13	dB

Hub Receive

Frequency	11.8	GHz
Satellite EIRP	52.4	dBW
Downlink PFD@ Beam Center(@52.4)	3.41	dBW/4kHz
Hub G/T	33.34	dB/oK
Path Loss	205.38	dB
Other Losses	0.09	dB

Transponder

Total OPBO	3	dB
Carrier OPBO	21.880	dB
C/No Thermal Up	65.250	dB-Hz
C/No Thermal Dn	86.280	dB-Hz
C/Io Total	62.684	dB-Hz
C/No+Io	60.760	dB-Hz
Add'l Link Margin	0.16	dB
% BW per cxr	4.56	%
% Power per cxr	1.29	%
Xpdr BW Alloc	2.46	MHz

ThinKom Antenna

Forward Link Budget

Hub	Beijing Hub	
Required Eb/No	1.7	dB
Modulation	QPSK	
Info Rate	4	Mbps
FEC Rate	0.5	
Carrier Rolloff	1.2	
Satellite SFD @ 0 dB/K	-98.4	dBW/m2
Transponder Atten	8	dB
Transponder ID	AS7 POR	

Hub Transmit

Frequency	14.145	GHz
Satellite G/T	5.4	dB/oK
Antenna Diameter	6.3	m
Carrier EIRP	48.24	dBW
Ant. Input PFD	-38.59	dBW/4kHz
Path Loss	206.96	dB
Atm/Point/Pol Loss	0.12	dB

Aircraft Receive Terminal

Frequency	11.8	GHz
Satellite EIRP	46	dBW
Downlink PFD@ Beam Center(@54)	2.31	dBW/4kHz
Receive Gain	32.6	dB
Terminal G/T	14.22	dB/oK
Path Loss	205.57	dB
Other Losses	0.11	dB

Transponder

Total OPBO	3	dB
Carrier OPBO	13.67	dB
C/No Thermal Up	74.47	dB-Hz
C/No Thermal Dn	68.97	dB-Hz
C/Io Total	81.82	dB-Hz
C/No+Io	67.72	dB-Hz
Add'l Link Margin	0	dB
% BW per cxr	8.89	%
% Power per cxr	8.58	%
Xpdr BW Alloc	54	MHz

Return Link Budget

Terminal	AES-2	
Required Eb/No	3.5	dB
Modulation	BPSK	
Info Rate	1	Mbps
FEC Rate	0.5	
Carrier Spacing	1.2	
Carrier Spreading	NA	
Satellite SFD @ 0 dB/K	-93	dBW/m2
Transponder Atten	8	dB
Transponder ID	LTWTA	

Aircraft Transmit Terminal

Frequency	14.145	GHz
Satellite G/T	0	dB/oK
Antenna Diameter	0.74	m
Carrier EIRP	45.44	dBW
Ant Input PFD	-13.22	dBW/4kHz
Path Loss	207.14	dB
Atm/Point/Pol Loss	0.13	dB

Hub Receive

Frequency	11.8	GHz
Satellite EIRP	52.4	dBW
Downlink PFD@ Beam Center(@52.4)	3.42	dBW/4kHz
Hub G/T	33.34	dB/oK
Path Loss	205.38	dB
Other Losses	0.09	dB

Transponder

Total OPBO	3	dB
Carrier OPBO	21.960	dB
C/No Thermal Up	66.170	dB-Hz
C/No Thermal Dn	86.200	dB-Hz
C/Io Total	73.549	dB-Hz
C/No+Io	65.400	dB-Hz
Add'l Link Margin	1.9	dB
% BW per cxr	4.44	%
% Power per cxr	1.27	%
Xpdr BW Alloc	2.4	MHz

ANNEX 5.5.C: AsiaSat 7 Orbital Debris Mitigation Statement

AsiaSat 7 Orbital Debris Mitigation Plan

47 C.F.R. Section 25.114(d)(14): A description of the design and operational strategies that will be used to mitigate orbital debris, including the following information:

(i) A statement that the space station operator has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal;

(ii) A statement that the space station operator has assessed and limited the probability of accidental explosions during and after completion of mission operations. This statement must include a demonstration that debris generation will not result from the conversion of energy sources on board the spacecraft into energy that fragments the spacecraft. Energy sources include chemical, pressure, and kinetic energy. This demonstration should address whether stored energy will be removed at the spacecraft's end of life, by depleting residual fuel and leaving all fuel line valves open, venting any pressurized system, leaving all batteries in a permanent discharge state, and removing any remaining source of stored energy, or through other equivalent procedures specifically disclosed in the application;

(iii) A statement that the space station operator has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations. Where a space station will be launched into a low-Earth orbit that is identical, or very similar, to an orbit used by other space stations, the statement must include an analysis of the potential risk of collision and a description of what measures the space station operator plans to take to avoid in-orbit collisions. If the space station operator is relying on coordination with another system, the statement must indicate what steps have been taken to contact, and ascertain the likelihood of successful coordination of physical operations with, the other system. The statement must disclose the accuracy—if any—with which orbital parameters of non-geostationary satellite orbit space stations will be maintained, including apogee, perigee, inclination, and the right ascension of the ascending node(s). In the event that a system is not able to maintain orbital tolerances, *i.e.*, it lacks a propulsion system for orbital maintenance, that fact should be included in the debris mitigation disclosure. Such systems must also indicate the anticipated evolution over time of the orbit of the proposed satellite or satellites. Where a space station requests the assignment of a geostationary-Earth orbit location, it must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location, such that the station keeping volumes of the respective satellites might overlap. If so, the statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions;

(iv) A statement detailing the post-mission disposal plans for the space station at end of life, including the quantity of fuel—if any—that will be reserved for post-mission disposal maneuvers. For geostationary-Earth orbit space stations, the statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude. The statement must also include a casualty risk assessment if planned post-mission disposal

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involves atmospheric re-entry of the space station. In general, an assessment should include an estimate as to whether portions of the spacecraft will survive re-entry and reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty.

The AsiaSat 7 spacecraft is a reliable Space Systems/Loral ("SSL") 1300 spacecraft, which is widely known as a mature product and one of the most reliable satellite platforms, and is designed and has been demonstrated to withstand the harsh space environment. AsiaSat 7 is built on the same platform as AsiaSat 5, which has already been authorized by the FCC to communicate with ESAA terminals. In general, the SSL 1300 spacecraft design has taken orbital debris mitigation into account and is aligned with general industry practices and standards.

(i) Debris Release Assessment

AsiaSat has assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal. The satellite has been designed such that no debris will be released by the spacecraft under the normal operation of the satellite. In the event of collisions with small debris or meteoroids, the spacecraft hardware has been designed with redundant units such that individual faults will not cause the loss of the entire spacecraft and the spacecraft will retain the post-mission disposal capability. All critical components (e.g. on-board processors and control devices etc.) have been built within the structure and shielded from external influences. External items that could not be installed within the spacecraft structure nor shielded (e.g. antennas and attitude sensors etc.) are able to withstand impact. The spacecraft can be controlled through both the normal communications payload antennas and the wide angle omni antennas. The likelihood of both being damaged during a collision with small debris or meteoroids is minimal.

(ii) Accidental Explosion Assessment

AsiaSat has assessed and limited the probability of accidental explosions during and after completion of mission operations. The failure modes for all equipment have been reviewed to assess the possibility of an accidental explosion onboard the spacecraft. In order to ensure that the spacecraft does not explode on-orbit AsiaSat will continue to operate the satellite in accordance with SSL's recommended procedures. All batteries and propellant tanks are monitored for pressure or temperature variations. All critical satellite parameters are telemetered from the spacecraft and limits are checked by the real-time computers in the SOC (Satellite Operations Centre) and any out-of-limit conditions will alert the on-duty SOC controllers to take the required action. Additionally, long term trending analysis will be performed to monitor for any unexpected or anomalous trends.

Batteries are operated under SSL's automatic recharging scheme. This means normal battery charging termination does not require ground commanding to ensure no additional heat and pressure build up in the battery cells. Furthermore, each battery cell is protected by individual over voltage and over current protection circuits. As this process occurs wholly within the spacecraft, it also affords protection from command link failures from the ground station.

To protect the propulsion subsystem, propellant tanks are operated in a blow down mode during on-orbit operation. At the completion of orbit raising, the pressurant was isolated from the propellant tanks. Therefore the pressure in the propellant tanks will decrease as the propellant is consumed during the stationkeeping manoeuvres over the life of the spacecraft. There is also a regulator installed between the pressurant tanks and the propellant tanks such that if a pressure valve fails open the propellant tanks would not be over-pressurized.

To ensure that the spacecraft has no explosive risk after it has been successfully de-orbited, all stored energy onboard the spacecraft will be removed. Firstly, all latch valves will be open to ensure all residual propellant and pressurant are vented out and released. All battery chargers will be turned off and batteries will be left in a permanent discharge state. All remaining active pyrotechnics will be fired to eliminate explosive risk. All reaction wheels will be turned off to release all stored kinetic energy. These steps will ensure that no buildup of energy can occur resulting in an explosion in the years after the spacecraft is de-orbited.

(iii) Assessment Regarding Collision with Large Debris and Other Space Stations

AsiaSat has assessed and limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations.

AsiaSat 7 is operating at GEO at longitude of 105.5 deg E +/-0.1 deg and using industry standard and time proven techniques in the station-keeping maneuvering and orbit determination. These are the same techniques that AsiaSat has and continues to use for all its spacecraft fleet.

To minimize the possibility of a large body impact collision, the proximity of other known Space Stations/satellites has been assessed. In addition to working with other satellite operators of all known neighbouring satellites, AsiaSat utilizes other methods to identify the collision risk. All satellites in GEO or near GEO are tracked by downloading the orbital parameters from the NORAD database every day, and an internal satellite movement report is generated to AsiaSat's Engineering and Operations staff. AsiaSat will also get alerts from the JSpOC for any approaching bodies.

Any new spacecraft launch or satellite relocation will be closely monitored to verify that no new spacecraft will be introduced in the vicinity of AsiaSat 7. In the event that some spacecraft does locate within the vicinity of AsiaSat 7, AsiaSat will coordinate and work closely with that satellite operator on orbit control and stationkeeping strategies as it has done in the past with many other operators.

(iv) Post-Mission Disposal Plans

As a licensed satellite operator in Hong Kong, AsiaSat complies with the requirements as stipulated by the "Guidelines for De-commissioning of Satellite" (the "Guidelines") issued by OFCA (Hong Kong Office of Communications Authority) and adheres to prevailing international best practices and standards to reduce space debris.

According to the Guidelines, which are also consistent with the FCC requirement in §25.283 of the Commission's rules pertaining to end-of-life satellite disposal, any expired satellite which has to be

ANNEX 5.5.C: AsiaSat 7 Orbital Debris Mitigation Statement

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de-orbited to outer space shall be disposed to an orbit with a delta-perigee (Δa) higher than geosynchronous orbit of no less than:

$$235 \text{ km} + (1000 \times CR \times A/m)$$

where CR is the solar pressure radiation coefficient of the spacecraft, and A/m is the area-to-mass ratio, in square meters per kilogram, of the spacecraft.

AsiaSat will take into account this requirement for any de-orbit of the AsiaSat 7 satellite and will reserve sufficient propellant in order to conform to the regulations set forth in the Guidelines:

	Δa requirement	Propellant Needed
AsiaSat 7	277 km	6.65 kg

Any remaining propellant will be consumed by further raising the orbit until combustion is no longer possible. The remaining species of propellant, i.e. Oxidizer (N2O4) or Fuel (MMH), will be vented, placing the spacecraft's propulsion subsystem in a "safe" state.

Propellant tracking is accomplished using a bookkeeping method. This method will track the number of jet seconds utilized for stationkeeping, momentum control and other attitude control events. From jet seconds, amount of propellant consumed is determined. This process has been calibrated using data collected from thruster tests conducted on the ground.

Asia Satellite Telecommunications Company Limited

[signature]

[Name] William Ma
[Title] Satellite Engineering & Orbital Dynamics Manager

ANNEX 6:

Gogo Certifications

Gogo LLC ("Gogo"), in support of the foregoing application to modify the Gogo ESAA License, hereby certifies as follows:

1. With the exception of AMC-1, Gogo's target space station operators have confirmed that Gogo's proposed ESAA operations over international waters are within coordinated parameters for adjacent satellites up to 6 degrees away on the geostationary arc.
2. Gogo will comply with the requirements contained in paragraphs (a)(6), (a)(9), (a)(10), and (a)(11) of Section 25.227 of the Commission's rules, 47 C.F.R. § 25.227.

By: /s/ Timothy Joyce
Timothy Joyce
VP of RF Engineering
Gogo LLC

October 22, 2015